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Materials & Methods

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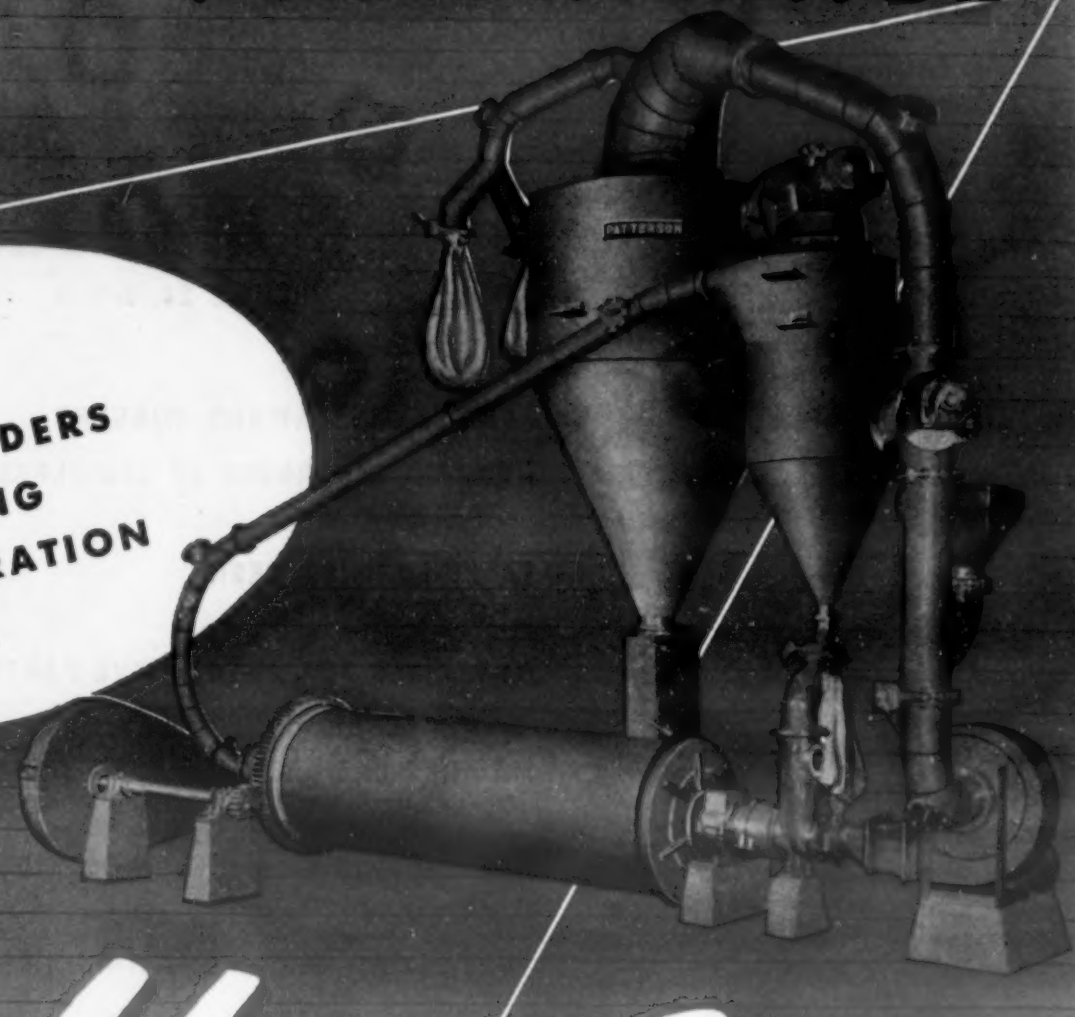

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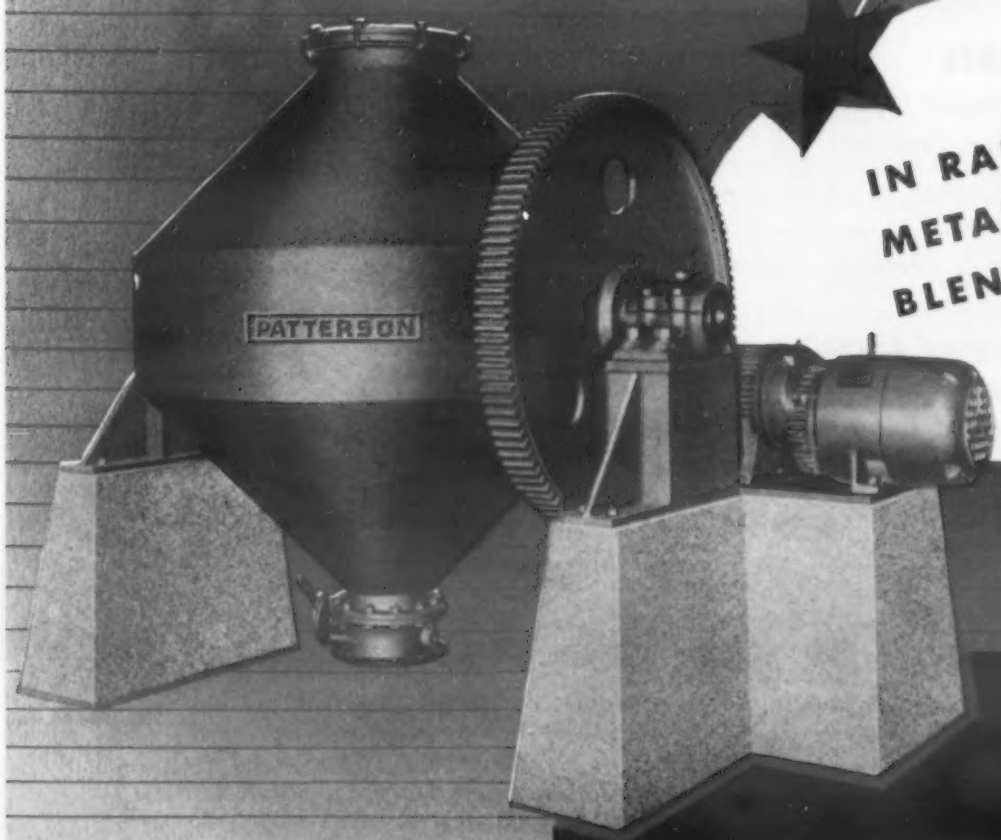

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The MATERIALS OUTLOOK...

Fiberglas Going Many Places

Fiberglas yarns and textiles are apparently going places, especially since the price reduction of 20 to 25% last summer. Besides its important use for electrical insulation, a prominent application is in plastic lamination. One weaver advertises 21 standard fabrics, light to heavy weight; stronger than steel, even at high temperatures; fireproof; resistant to moisture, mildew and most acids; it will not stretch nor shrink and has high impact strength. Some recent applications are welding curtains, protective coverings in the marine field, shims and gaskets exposed to the elements. A happy use is for nonsqueak shims between fenders and automobile bodies. Cotton is its closest competitor, with some Fiberglas even cheaper than cotton—yet price is a minor consideration. Sources of supply have recently become much broader as Owens-Corning now confines itself to yarn manufacture, encouraging several new weavers and fabricators to start up.

Merging Steel Designations

Final moves are afoot to bring the steel classification systems of the American Iron & Steel Institute and the Society of Automotive Engineers into agreement. As regards plain carbon steel and most alloy compositions, the SAE classifications have become so well established over 35 years that AISI compositions will be brought into agreement with SAE. In stainless steel, AISI classifications have been outstanding and will be retained, with prefix 30 to indicate chromium-nickel austenitic steels and with 51 prefixed to AISI type numbers for chromium irons.

Stainless-Clad for Auto Grilles

Stainless-clad for grille work and hardware in automobiles is being watched closely by those who have been furnishing zinc base die castings, chromium-plated. Stainless is finding favor with several large automobile manufacturers. Stainless-clad might seem a "natural" for this application for there is no plate to peel off or corrode through, the material being a homogeneous one by nature. The chromium platers may come up with a better product.

Oxide-Free Aluminum Powder

A prominent maker of bearing metals and alloys for the automotive industry has been asking loudly for an oxide-free aluminum powder. A powder metallurgy concern has promised to deliver such a powder before the turn of the year. As this is written, the powder is being produced in a laboratory, with a pilot plant as the next anticipated stage.

Cobalt's Peace Use Large

Despite the large consumption of cobalt during the war, particularly for alloying into high temperature compositions for aircraft superchargers, jet engines and other turbine applications, postwar demand is proving even greater. Thus, in magnets 1,456,522 lb. were used in 1946, a gain of 32% over the previous year and representing 35% of all cobalt used. There is a growing use in welding rods, die and valve steel and stock for tipping tools. We need not worry over native supplies for many years since the United States has reserves for 50 years at present consumption rates. The Belgian Congo is the chief foreign source, with Belgium second.

Palladium Creeps Up on Platinum

Domestic consumption of palladium in 1946 soared to over 90% of platinum as against 40% in 1938. One of the many good reasons is that it is often more economical; a little of the metal does a big job. Lighter in weight and lower in cost than comparable metals, palladium makes possible lower unit costs. A unit of palladium weighing 1/1000 oz. would cost about 2½c. The most important use is for small electrical contacts to operate with light pressure in apparatus functioning for long periods without servicing. For larger contacts, bi-metallic strips with a palladium facing are used. These are made by bonding the precious metal to a base metal. In finely divided form, usually applied to a suitable support, palladium is an exceptionally efficient hydrogenation catalyst which often permits safer operation of processes at lower temperature and pressure.

Darkness, Then Dawn, in Magnesium

Though magnesium consumption is now at the lowest point since V-J Day, or 1,500,000 lb. monthly, a survey among managers of magnesium producing companies shows marked optimism for the future. Thus, the consensus of opinion a few weeks back involved the following schedule of production: Aug. 1, 49% of capacity; Sept. 15, 72%; Jan. 1, 1948, 84%. By July 1, 1948, they predict production of 50,000,000 lb. annually against 5,000,000 in 1939.

Cast Iron Parts to the Fore

Cast iron will be winning back applications which it lost to other materials in view of the improved quality in recent years, what with tensile strengths as high as 60,000 psi. against 20,000 formerly and other physicals improving accordingly. New or revived applications will be castings in collets and holding fixtures because of elastic qualities; in tool shanks and miller cutter bodies, to increase vibration absorption, strength, rigidity and heat conductivity; in die material, and for high temperature and wear resistance applications. In one case cast iron replaced a part of a tool previously machined from a bar of SAE 1045 steel. Again, casting of parts reduces machining; the graphite content provides lubrication in dies. In designing modern cast iron parts, stress analysis has been used to assure economical design and reduction in weight.

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Production Frontiers

by Harold A. Knight *News Editor*

All-Out for Peace, as for War

We cannot be internationally-minded in some respects and purely domestically-minded in others. Modern peace like modern war is an all-out proposition. When last June certain congressmen were agitating a high duty on wool, for instance, they were still bound in their mental processes by the false premises of yesterday. Every American citizen is essentially a child of yesterday, hence we are constantly taken by surprise in the discovery that events change faster than we can change our minds.

With these introductory thoughts, Brooks Emeny, president, Foreign Policy Assn., spoke at a dinner in honor of visitors from overseas before the 1947 Machine Tool Show. His subject was "The Tools of Reconstruction." We had lived in a mid-western city some seven years ago when Mr. Emeny was locally, at least, the most highly-thought-of speaker on world affairs. We have wondered why we had not encountered him since. When we learned he would address the machine toolers we knew the program chairman had been wise.

An important factor in modern world relations is the power position of the United States. With a population of scarcely 6% of the world's, this nation has emerged with 50 to 70% of the world's industrial might, financial wealth, naval, military and air strength. Moreover, there are now but three great powers: the British Empire, the United States, and the Soviet Union. It had been a seven-power world—and there is "safety in numbers."

Europe for the first time in modern history is truly prostrate. Again, the relative strength of Britain has so declined that she is incapable of assuming her traditional role of the world's policeman around the marginal seas of Eurasia. Nearly 70% of mankind lives in vacuum areas, the vast majority of these unhappy people being politically immature. They can become easy victims of the Utopian promises of Communist propaganda.

Revolting against intolerable conditions of life of the past, they cannot always distinguish between the theory of the proletarian heaven and the reality of slave labor under the police state. If they were docile the situation would be better, but they have become awakened and are today in revolt. And Moscow, whose strength lies in ability to feed on human misery, stands ready to be the ruthless beneficiary.

A few scientific minds are uncovering secrets that can destroy humanity at a time when mankind is unprepared for development of international, political, social and economic controls necessary for self-preservation. National sovereignty can no longer protect the security of peoples. Even America is too puny to guarantee alone the safety of its citizens. How to make the necessary transition from national sovereignty concepts to those of world government is the major dilemma of the age.

In working out a world system we start with the terrific handicap involved in the lack of common principles, ideologies, standards and ideals which motivate different nations.

The statesmen of the three big powers are still being motivated, not by ideas of world government, but by the jealousies and fears of each toward the other. One often wonders how completely the entire climate of world conditions would alter were the Kremlin to see the wisdom of releasing its people from the tyranny of fear, returning to mutual accommodation, trust and confidence.

America has been engaged in a holding action, with the Soviets consistently on the offensive. There is an indication, at long last, that our government is planning seriously overall strategy via the Marshall plan. We are getting away from improvisation to a more fundamental approach. We have recovered from our first shock of the cynicism and sinister nature of traditional power politics. We have never before had to face in all its unvarnished form the old style

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of power politics in which Russia and the other powers have long been so adept.

The American people are seeing more clearly that wherever economic distress, low standards of living and starvation prevail, the entering wedge of the police state is surely set. It is the Soviets, not the Americans, who have declared that Communism and Capitalism cannot exist together. Our new policy is one of "containment." Only by erection of such barriers can Russia be brought to accept the idea that Communism and Democracy can live in the same world. We have concluded that the world can no longer afford the postponement of reconstruction and alleviation of human suffering through Russian opposition alone.

Comments on Taft-Hartley Law

We have heard several interesting comments recently on the Taft-Hartley law and various reactions to the law on the part of a wide assortment of people.

E. J. Thomas, president, Goodyear Tire & Rubber Co., when addressing a trade association convention, stated that a recent public opinion poll showed a majority sentiment against the measure while a series of detailed check questions that followed found the great majority strongly favored the most important of the specific provisions of the law.

"Undoubtedly, the explanation is found in the volume of misinformation pumped out under great pressure by union and party opposition spokesmen," opined Mr. Thomas. "They used such catch phrases as 'slave labor,' 'anti-union,' 'Tory,' etc. They used every possible medium of communication to build up their case."

Illustrating the tendency of workers to disapprove the law in its entirety, while favoring certain features, is a story told by Claude Robinson, president, Opinion Research Corp.

"And how did you enjoy your meal, sir?" the waiter beams.

"No good," snaps the customer, rising from his table.

The waiter's face falls in disappointment. "The beef was overdone?" he inquires timidly.

"Nope. Beef was fine."

"Then it was the appetizer? Perhaps a little too—"

"Not at all," cuts in the customer. "The shrimps were tasty."

"It must have been the soup."

"Wrong again. The soup was delicious."

"That leaves the salad? . . . the dessert? . . . the coffee?"

"No."

A brief but significant pause. Bewildered, the waiter stares dully into the dead pan of his customer. Then, as if reciting from memory, he says slowly: "I see. Every course was good. But . . . you . . . didn't . . . like . . . the . . . meal." The customer nods. "That's right. I didn't like the meal."

E. B. Gallaher, writing for publications of the Army Ordnance Assn., stated that when the law became effective hundreds of columns in the press were devoted to articles, interviews and speeches by labor leaders who talked of the "enslavement" of labor by capital. "How many individual businessmen have come forward to challenge these fakes?" he asks.

"What we need to combat these lies are more case histories giving facts and figures; and these should be presented by some individual of authority in his company over his signature in the public press or over the radio."

Meanwhile, Representative Fred A. Hartley, Jr., co-sponsor of the bill, is vigorously urging employers to make immediate good use of their restored "free speech" right to acquaint their employees with the provisions of the new law. He also points out that terms of the bill were badly misrepresented during the campaign to prevent its passage. Hence, few workers realize that the act is as much to their benefit as it is to their employer's.

The Labor Relations Institute, New York, suggests that every employer give every employee a folder telling exactly what the employer, employee and union can—and cannot—do under the law, the Institute itself having prepared a typical folder.

The Institute also lists eight symptoms of a worker's slowdown: (1) There is a decline in incentive earnings based on standards of production; (2) if straight piecework earnings are too nearly uniform, indicating agreements to "peg" earnings to specified maximums; (3) if unit labor costs are rising more rapidly than the bill for wages; (4) if machine breakdowns and stockroom calls are above normal; (5) if there is a drop in electrical consumption; (6) if the number of scrapped and rejected parts is rising; (7) if more than usual time is spent in washrooms; (8) if tardiness and early quitting are increasing.

The Institute suggests four steps to combat the slowdown psychology: (1) Keep workers informed about all pending changes in work methods and machinery, removing fears from workers' minds; (2) establish wage incentives or a means of "selling" job simplification and technological improvements; (3) impress foremen with need for careful supervision and in detecting impending slowdowns; (4) overhaul the grievance machinery so that gripes are reported quickly to management before they are translated into slowdowns.

Rubies and Other Aluminum Oxides

There's quite a bit in the press these days about artificial rubies and sapphires for industrial and jewelry use. We refer, for instance, to the feature article, "Bonding Sapphires to Metal" in MATERIALS & METHODS, October, 1947 and—not to be outdone by M&M—a piece in a recent issue of *Saturday Evening Post*. Newspapers, too, have written of the exhibit of these artificial gems and tools sponsored by the Linde Air Products Co.

Timely, therefore, is a report of the technical accomplishments along these lines of a German scientist, Dr. Eugene Ryschkewitch, who developed a sintered ruby tool that did work impossible for several steel grinding tools. It was necessary to face on both sides 12 hard rubber plates, 1 meter dia. Steel tools were completely ruined without affecting even a fraction of the surface of the rubber. A single ruby tool faced 24 sides of the plates satisfactorily, quickly and cheaply.

A report, held confidential until recently, outlines the accomplishments of Dr. Ryschkewitch in 20 years of extensive research in ceramics, the report being on sale by the Office of Technical Services, Department of Commerce, Washington.

Written in English, the report describes the scientist's basic research in the development of ceramics products from pure oxides, including development of suitable high temperature furnaces. Just prior to the war the German opened a plant for making aluminum oxide (sintered alumina or sintered corundum) products.

Pure sintered alumina, he says, is

a valuable material, destined for frequent use in cases where progress is limited by present day techniques and materials. Aluminum oxide is superior to all ceramic materials to date for pyrometer protection tubes, while sintered corundum has become very important for insulators for heavy duty spark plugs, such as in aircraft. A possible application of sintered alumina is for blades for gas turbines.

Before the war the doctor used sintered alumina for cutting tools because of its great mechanical strength and hardness. At one plant aluminum blocks were machined by ceramic tools without alcohol. At another place a cutting speed for silumin of 1000 meters a min. was possible.

Other research was concerned with oxides of zirconium and beryllium, the strength of ceramic materials and high refractory hard carbides. For the U.S.A. Dr. Ryschkewitch recommends starting a research institute closely coordinated with industry at a large university for the development of new ceramic materials, chiefly of highly refractory oxides, carbides and other such materials.

Aluminum's Ascendancy—and Why

Among the most spectacular growths of an engineering material during the war and since has been that of aluminum. Scarcely a day passes but that one hears of a new application. Recently we learned that Ford has substituted aluminum running boards and headlamp housings, and is experimenting with 60 or 70 other automobile parts. Kaiser-Fraser will make gasoline tanks of aluminum, thus saving 22 lb. of steel per car. Chevrolet is producing a new package delivery truck body of aluminum alloy on monococque principles to eliminate interior upright braces, saving 1000 lb.

Automobile manufacturers have experimented with aluminum deck lids and hoods for the 1948 models, with the possibility of application to hardware, hub caps and grilles. It can be chromium plated as cheaply as steel, it is said. Though the metal has been used in distributor gears for some time, its use in moving parts of the engine has been limited generally to pistons. Alcoa at Cleveland is experimenting with an all-aluminum engine, weighing 175 lb. less than the conventional engine.

It is being tested in major "unsprung" assemblies of automobiles; also for brake drums. Admittedly, much of the application of aluminum is due to scarcity of steel, yet many substitutions promise to stick.

When considering aluminum as a cost competitor of other metals, a handy reference is a chart that appeared in the *American Metal Market,* which compares metal prices on a volumetric basis. Aluminum became cheaper than copper permanently in 1933, becoming cheaper than zinc at mid-1941. Aluminum and copper were farthest apart during this century in 1917, while aluminum and zinc had the greatest difference in 1907. Only in one brief era was copper cheaper than aluminum, or from mid-1931 to Jan. 1, 1933 when the actual copper price reached an all-time low of 5 cents per lb.

According to a volumetric basis price comparison, aluminum is now about 4¾ cents per lb. against 8¾ cents for zinc and 21½ cents for copper, the price of copper having been chosen as the basis for comparison. It is assumed that the weight of a cubic foot of aluminum is 169 lb.; of zinc, 440 lb.; of copper, 556 lb. The factor for aluminum is 0.303 and for zinc 0.79.

In comparing aluminum and steel costs, George W. Birdsall, of Reynolds Metal Co., comments on their new aluminum sheet material at prices 15% below any aluminum previously offered the sheet metal industries. He points out, for example, that in fabricating duct work a pound of this new aluminum sheet at 21.4 cents is equivalent to conventional materials at 7.1 cents per lb. He suggests that if the fabricator is paying more than 7 cents for his present heavier conventional material, he would do well to investigate aluminum.

Ordnance Wants New Materials

Once every year for 29 years now, members of the Army Ordnance Association have treked to Aberdeen, Md., Army's largest proving grounds, to witness the very latest developments in modern fighting equipment. The avowed purpose is to show and review the results of the industry-ordnance team's concerted effort to maintain our national security.

At this year's demonstration, on October 2, something new was added. Not only were the latest weapons displayed, but they were also demonstrated under simulated combat conditions. Just a few hundred feet in front of us a full scale battle was staged in which an infantry battalion used practically every weapon at the command of the United States Army to destroy and capture a group of mock fortifications.

Although this was the most spectacular part of the program, the most important thing from our standpoint and yours that came out of this year's meeting was the revelation that right now ordnance vitally needs better materials. The Army Ordnance Association listed 12 immediate problems that Ordnance is confronted with, and nearly half of these are directly concerned with materials. Here are a few things they are looking for. They need stronger, tougher metals, metals that will maintain their strength and resistance to impact in a wide range of the temperature represented at one extreme by the cold of the Arctic and at the other by the flame of the rocket or jet.

They need improved light-weight metals. The wider use of air transport for weapons and vehicular equipment makes increasingly important a reduction of weight of many types of material. The development of light-weight alloys with improved abrasion resistance and better corrosion resistance would make possible their use in suspension and track components and other structural members not required for protection from gun fire. They also need materials to withstand gases at high temperatures and pressure for parts such as nozzles in long-range missiles, artillery type and air-to-air rockets, certain types of mortars, and in recoilless rifles.

And they need better armor materials. In the classic battle between armor and projectile, the projectile is now ahead. Previous to World War II, armor was synonymous with steel. Today armor may be of steel, light metal alloys, plastics and even a mixture of crushed stone and asphalt. Although it is possible theoretically to armor a tank against attack by any weapon which can probably be brought to bear on it, the tank would be rendered helpless by its own sheer weight. The problem, therefore, is to develop light-weight resistant armor that will protect vehicles and still keep them fast and maneuverable in battle.

EDITORIAL COMMENT

Quality of Steels Today

This may be in the nature of perpetuating a rumor, but if the facts are true, they should be brought to light.

The other night on a commuting train two business men were discussing steel and the fact that sheet quality was generally below standard. As one man explained it to the other, steel mills were paying production bonuses to labor regardless of whether or not the steel turned out was of a quality high enough to meet standards.

Rumblings about steel quality can be heard in all directions. A survey, the results of which we published in July, disclosed that many users were dissatisfied with the quality of steel being obtained. Many respondents claimed that poor surface quality made necessary many extra surface treatments to obtain a finish which was passable.

If, as is claimed, steel quality is poor, the mills should revise their practices. Many producers of metal products are now being driven to other metals because of scarcities. Lower quality of steel will only serve to hasten such switch-overs, many of which will be permanent.

If the charges are false, steel producers should do all in their power to put the true facts before the public.

Poor quality merchandise and greatly increased prices doubles the effect of inflationary trends and greatly reduces the standard of living.

—T.C.D.

It's a Hard, Clever World

This is a clever world in which we live and one has to keep on his toes every minute so as not to be outdone. In international dealings, especially, the going is tricky, we are in fast company, and to hold our own requires all our Yankee ingenuity.

Take this thing called Good Will, for example. Good will between countries is a wonderful thing, but like practically everything else, it costs money. You have to buy it. Early this year you may have noticed that the United States dickered with Bolivia for a large share of her tin. Bolivia demanded 76c a lb., but although we were starving for tin, we refused to go higher than 67c a lb., and so the deal was off for the time being. Since tin is the only important industry in Bolivia, the flow of good will between the two countries, no doubt, was considerably reduced.

At this critical moment, Argentina was on her diplomatic toes and immediately made a deal to buy 8000 tons of tin a year from Bolivia for five years at 76c per lb. This seemed to be a foolish thing for Argentina to do, because she has practically no tin smelters (only 850 tons annual capacity). But the deal wasn't as curious at it might have seemed at first glance. Senor Peron was very much interested in diverting that flow of good will between Bolivia and United States to Argentina, and this seemed like an excellent opportunity to do it. After the Argentina-Bolivia agreement was reached, we dickered some more with Bolivia and belatedly agreed to buy approximately 10,000 tons this year at Bolivia's own price of 76c per lb. So probably a little good will was recaptured.

But what will Argentina do with all that tin? Buying 8000 tons of good will at 76c a lb. is quite expensive. The guess, and it is a pretty good one, is that Senor Peron will try to resell the tin for at least as much as he paid for it. And who knows, if we can't get the tin we need from Malaya and the Netherlands East Indies, he may even resell it to us. If this should happen, our faces would certainly turn a deep red. For we would then not only have lost some good will with Bolivia, but we would also be paying for Argentina's little good will transaction with that country.

Yes, this is a clever world, and it's a hard, fast crowd we are in with.

—H.R.C.

Shadow on Chromium Plating

One does not require good eyesight to realize the large proportion of the surface of a modern automobile that is chromium plated metal. Neither does one require 20-20 eyesight to see how badly much of this chromium has deteriorated on models as recent as 1946. Ugly rust spots have perforated the once beautiful bumpers and grill work, and portions of the chromium have chipped or peeled off. Otherwise, cars in apparently near-perfect condition have the appearance of being, perhaps, 7 years old because of this defective chromium work.

We'll admit that we have made our observations in a salt water atmosphere community, but in view of the millions of automobiles that operate in such climates one must consider the problem serious and inexcusable.

Either the chromium coating was not thick enough, or the underlying metal is not correct, or the processing faulty, or the owner has been unduly neglectful. As to the last, proper materials and processing assume a certain amount of owner neglect.

Usually when there are failures of a metal coating, the chief remedy thereafter is to apply a thicker coating, we believe. Some 15 years ago makers of galvanized sheets were applying thinner and thinner coatings of zinc in the competition to sell cheaply. Things came to a pretty pass and the product was losing prestige rapidly.

Thereupon the American Zinc Institute took it upon itself to campaign for thicker coatings of zinc. They bestowed the "Seal of Quality" emblem upon all producers of galvanized sheets who used a certain minimum ounces of zinc coating per square foot of steel sheet. Soon the product became universally better and the industry saved itself from ignominy and popular distrust.

Can't the same thing be done with chromium plating, either through the Electrochemical Society, Electroplaters Society, or some newly-organized commercial trade association?

Chromium is a beautiful and highly useful metal, as those who know metals fully realize. Isn't it high time, therefore, that a campaign be inaugurated for better products involving chromium for plating before the public becomes disgusted and insists on other materials for its decoration?

—H.A.K.

Eleven years ago, Horace Blackwell came to Inland from an Indiana farm. Seven years later he had moved up from laborer, through pit man, mold inspector, and expediter, to pit foreman of No. 1 Open Hearth—in charge of a crew of thirty. Blackwell is only one of many young men at Inland . . . intelligent and ambitious . . . who are forging careers for themselves in the Inland mills . . . helping to turn out quality steels to your exacting specifications. INLAND STEEL CO., 38 S. Dearborn St., Chicago 3, Ill. Offices: Detroit, Indianapolis, Kansas City, Milwaukee, New York, St. Louis, St. Paul.

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Introducing INLAND'S "MEN OF STEEL"

Materials & Methods
THE METALWORKING INDUSTRIES' ENGINEERING MAGAZINE
NOVEMBER 1947

Cledo Brunetti Receives 1947 Materials & Methods Achievement Award

Special Awards Made to Latrobe and to Republic Steel—Arthur D. Little

Honorable Mentions to Five Others

Because the primary problem facing industry today is the discovery of means of lowering the manufacturing cost of its products, primarily through increasing production, the results of the 1947 Materials & Methods Achievement Award are of special significance. Readers will recall that the Award was established to foster and encourage skillful and enlightened use of materials in product manufacturing, by honoring those doing outstanding work in the application, processing and development of engineering materials. For 1947 the special "theme" has been *cost reduction,* and the GRAND AWARD is being made for the most significant use of modern engineering materials and processing methods to increase the production and lower the cost of products now being manufactured.

Two SPECIAL AWARDS are also conferred this year —one for the development of new materials that aid cost reduction and the other for the development of new methods for processing materials with lowered costs. In addition, five HONORABLE MENTION Awards are given to the next five most meritorious achievements in cost reduction through either the application, processing or development of engineering materials.

The plaques and certificates were presented to the Award winners at a dinner at the Stevens Hotel in Chicago on October 22nd.

The Award Winners were chosen by an independent panel of distinguished engineers and production executives who studied and appraised a large field of excellent candidates before reaching their decisions. The final results for 1947 are as follows:

The Results

Grand Award for the most significant use of modern engineering materials and processing methods to increase the production and lower the cost of products now being manufactured
to: **Dr. Cledo Brunetti,** Chief, Engineering Electronics Section, National Bureau of Standards, Washington, D. C.
Achievement: The development of an ingenious system of *printing* rather than *wiring* electronic circuits, utilizing extremely compact ceramic, plastics or other nonmetallic plates printed with silver ink, which save space, production time, materials (especially conductor wire and solder), rejections and inspection time, and whose economic and new-product advantages may well revolutionize the radio industries

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Special Award for achievement in developing new engineering materials which result in higher production and lower cost of manufactured products
to: **Latrobe Electric Steel Co.,** Latrobe, Pa.
Achievement: The development of high-speed tool and die steels free from segregation, which have resulted in production and tool-life increases in users' plants as high as several hundred per cent

Special Award for achievement in developing or applying processes or processing equipment that increase production and lower the cost of manufactured products
to: **Republic Steel Corp.,** Cleveland
and
Arthur D. Little Inc., Cambridge, Mass.
jointly
Achievement: Development of a process for

operating pig iron blast furnaces under pressure, which increased the daily pig iron capacity of a furnace by 11 to 20% and reduced the manufacturing cost of pig iron $1.50 per ton

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Honorable Mentions

to: **C. G. Peters, W. B. Emerson, K. F. Nefflen, F. K. Harris & I. L. Cooter,** National Bureau of Standards, Washington, D. C.
Achievement: Development of a new electrical process, now widely used by the fine-wire diamond-die industry, for drilling small diamond dies, which shortens the overall die-polishing process by 100 hr., increases die production in some cases 5-fold and has actually established an American fine-wire diamond-die industry where none existed before

to: **Thermex Div., The Girdler Corp.,** Louisville, Ky.
Achievement: The application of high-frequency heating to the edge-bonding of wood panels, resulting in savings in one large fabricator's plant of $22,680 per year

to: **Motor Division, Westinghouse Electric Corp.,** Buffalo, N. Y.
Achievement: The complete breaking-away from traditional electric motor design, materials and manufacturing processes to produce a line of integral motors which provide required horsepower in a minimum size

to: **Rigid-Tex Corp.,** Buffalo, N. Y.
Achievement: The development of sheet metal products that are design-strengthened to increase their rigidity and produce a patterned surface, which permit lowered material and fabricating costs and lighter weight of product

to: **T. E. Eagan,** Cooper-Bessemer Corp., Grove City, Pa.
Achievement: The use of high strength cast iron for diesel engine crankshafts, with manufacturing labor economy of 40 to 50%, plus extra engineering advantages

The Judges

Much of the prestige and significance of the Materials & Methods Achievement Award stems from the eminence and competence of its Board of Judges. The publishers and editors of MATERIALS & METHODS, who have no influence whatever on the voting, are particularly proud of and grateful to this outstanding Committee of nationally-known authorities who contributed their time and brains to the judging of the 1947 Awards:

Ralph M. Heintz, Vice President, Jack & Heintz Precision Industries Inc., Cleveland, Ohio

Norman L. Mochel, Manager, Metallurgical Engineering, Westinghouse Electric Corp., Philadelphia, Pa.

Louis Polk, President of the Sheffield Corporation, Dayton, Ohio, and of Threadwell Tap & Die Co., Greenfield, Mass.

A. M. Sargent, President and General Manager, Pioneer Engineering & Mfg. Co., Detroit, Mich.

Walter Dorwin Teague, Industrial Designer, New York, N. Y.

Sam Tour, President, Sam Tour & Co., Inc., New York, N. Y.

John R. Townsend, Materials Engineer, Bell Telephone Laboratories, Murray Hill, N. J.

The Grand Award Achievement

The technical development that won for Dr. Brunetti the 1947 Materials & Methods Grand Award, while usually classed as an "electronics" project, is actually a masterful application of brilliant materials-and-process engineering to electronic products. "Printed electronic circuits" means the use of materials and fabricating methods that eliminate much of the cumbersome wiring and the soldering operations in electronic equipment manufacture, giving astonishingly compact sets, produced in a fraction of the conventional time and at lower cost.

Applied during the war in the development and construction of the Navy's widely publicized VT proximity fuze, printed-circuits are now invading the industries making radios, television sets, hearing aids and industrial electronic controls, where their space- and cost-saving advantages are expected by many to produce something approaching a technological revolution!

Manufacturers of electronic equipment have depended almost entirely on the laborious process of wiring sets together with copper wires, resistors and coils. Wiring represents one of the largest items of production cost. The wires must be cut to length, bent into shape, attached to soldering posts and individually soldered. Even the smallest conventional set has as many as 100 soldering operations. Dr. Brunetti's development of practical methods of actually *printing* or *stenciling* the sets as one would stencil an ordinary sign has provided manufacturers with a means of eliminating as much as 60% of the soldering and most of the wire needed for conventional electronic units. Using these new and simple materials and techniques, a single operator may turn out thousands of electronic plates per day.

At the National Bureau of Standards, a group under the direction of Dr. Cledo Brunetti studied various materials and methods for mechanization of chassis wiring. Several methods were found to be perfectly feasible from a production standpoint (see, for example, the article "Materials and Techniques for Printed Electrical Circuits," MATERIALS & METHODS, March 1947). Best known is the stenciled screen process in which the circuits are stenciled directly on a flat plate of suitable material (ceramics, plastics, paper, etc.), using silver paint for the wires, carbon paint for the resistors and tiny disk capacitors. The "wiring" and components may alternatively be

brushed or sprayed onto the dielectric surface.

In other methods, metal is sprayed into narrow grooves molded in a plastics chassis; or insulating surfaces may be silver-coated along stencil-stopped-off lines using chemical silvering processes; or metal may be evaporated on a stenciled insulating plate under vacuum; or a hot-die-stamping method may be used, in which the circuit is punched out of metal foil and attached to a plastic panel.

An important effect of printing circuits is to reduce wiring to two dimensions. A printed radio or electronic unit can be smaller than is possible by the conventional wire and soldering process. Inspection costs and rejects are practically eliminated as each unit is an exact reproduction of the master pattern. Manufacturing rates are unbelievably rapid.

Production lines for printing the sub-assemblies of radio fuzes were set up as early as 1945 to produce 5,000 sets per day. A British manufacturer has released information on a completely automatic machine for printing electronic and radio circuits, which "produce sets by the millions, if necessary, without the need of a wiring chart and without the use of any wiring. . . . Cost does not depend on the number of elements but solely on the size of the panel; components can be added or scrapped by adjusting the tool producing the molded plate . . . . sets come off the production line every 20 sec."

Several manufacturers are now engaged in the design and production of radios and electronic devices using printed circuits. The National Bureau of Standards has established a special laboratory on printed circuits under Dr. Brunetti's direction to advise manufacturers and others interested in applying the new techniques to their problems.

Some manufacturers use one process, some another. Dr. Brunetti's patent applications cover many fundamental details, most of which will be made available to industry without royalties. However the greater part of the techniques are available to everyone, for as Dr. Brunetti has stated "they are adaptations of processes long known and not patentable."

This is indeed "the most significant use of modern engineering materials and processing methods to increase the production and lower the cost of products now being manufactured," and we do hereby pay formal honor to Dr. Brunetti and his associates at the Bureau for its development!

DR. BRUNETTI is typical of that combination of brilliant engineering, high personal qualities and broad non-technical activities that more than anything else have made this country what it is today. Born 37 years ago in Minnesota, he received a B.E.E. (With High Distinction) from the University of Minnesota in 1932, and later his Ph. D. from the same institution. He has taught electrical engineering at Minnesota; directed electronics and electrical research at Lehigh; lectured in radio at George Washington University; been a consultant for several manufacturers, the New York World's Fair and NDRC. He joined the Bureau in 1930 and has successively served it as research associate, research and development engineer, alternate chief of the Radio & Electronics Development Section, organizer and head of Production Engineering Section, chief of Ordinance Engineering Section, and since early this year chief of the Engineering Electronics Section.

In 1941 he was cited by Eta Kappa Nu, national honorary electrical engineering society, as "America's Outstanding Young Electrical Engineer for 1941." He has earned more honors and awards than can be enumerated in this space, especially the Naval Ordnance Development Award, the War Department's Certificate for Outstanding Services, the OSRD Certificate of Appreciation of Services, and membership in Sigma Xi, Tau Beta Pi, Pi Tau Pi Sigma and Scabbard and Blade.

Dr. Brunetti is an active worker in several technical societies, and a member or chairman of technical committees of Institute of Radio Engineers, Joint Research & Development Board, Joint Aeronautical Board, American Standards Association and others. His list of publications is long enough to require a special bibliographic supplement to this issue, and includes five textbooks for the National Radio Institute.

While he is now internationally known for his development of printed circuits and for their application in the Navy's proximity fuze, Dr. Brunetti has other important technical achievements to his credit, particularly the Transitron Oscillator; his theory of oscillation of negative resistance oscillators; and much of his present work on vacuum tubes, selenium rectifiers, television-controlled devices, high-speed bearings, plastics and potting compounds.

In addition to all this, Dr. Brunetti is a human being who likes to swim, fish, play tennis, volley ball and badminton, and listen to good music. He has ridden an especially active and socially useful hobby in highway traffic safety, in which field he is a prolific writer, pamphleteer and lecturer. And he considers the technical education of our youth important enough in the general scheme of things to have served as a member of several committees at Lehigh and Minnesota.

Special Award to Latrobe

Latrobe Electric Steel Co. won the Special Award for new materials that help to lower costs by the development of high-speed tool and die steels free from segregation—so-called "Desegatized" steels—which have resulted in excellent production and tool-life increases in users' plants.

In high-speed and high alloy tool steels the non-uniform materials structure resulting from segregation has been a common cause of non-uniform properties, non-uniform heat treating response, erratic production performance and other deficiencies. In the specially-processed tool steels for which Latrobe won this Award, segregation is virtually eliminated. Comparative testing of Desegatized steels against conventional steels of the same analysis has demonstrated the superiority of the former with respect to uniformity of properties, heat-treat response, tool toughness, etc.

Among the tool-life increases reported were several like the following:

A can manufacturer using high-carbon, high-chromium steels for hammer dies for sealing cans stepped up his production from 100,000 units before the first grind to 5,400,000 units by switching to Desegatized steels. A producer of cold-headed automobile tappets reported a 100% increase in output per header die after a change from a conventional high-speed steel to the Desegatized material. A nail manufacturer adopted Desegatized 18-4-1 steel and upped his production time between grinds from 54 hr. to 190 hr. A manufacturer of high-speed cutting tools who was suffering considerable loss on forging his cutter blanks out of conventional high-speed steel was able virtually to eliminate this trouble by switching to Desegatized steel.

The cost-reducing advantages represented in these cases are obvious. Latrobe is to be congratulated on the contribution to manufacturing efficiency embodied in these tool and die steels.

Special Award to Republic and A. D. Little

The Republic Steel Corp. and Arthur D. Little, Inc. are joint winners of the Special Award for development or application of new material-working processes that boost production or lower costs. They collaborated in the development of high pressure processes for operating pig iron blast furnaces, which increased the daily pig iron capacity of a furnace and substantially reduced the cost of producing pig iron. The achievement is of special economic importance because pig iron is industry's most important basic raw material, and because the industries that use steel are urgently in need of every extra ton of iron or steel that the steel producers are capable of turning out.

These companies have teamed together to reverse the downward trend in blast-furnace productivity—increasing the iron production 11 to 20%, decreasing coke consumption 12% and substantially decreasing flue dust production. The magnitude of the achievement is indicated by the overall cost saving, which is estimated to be about $1.50 per ton of iron produced. The introduction of the hot blast over 40 years ago is generally agreed to be the last previous great step forward in blast-furnace practice.

Any increase in pig iron output is immediately reflected in an increase in steel production with consequent relief to the current steel shortage. Current high prices for scrap accentuate the importance of the blast furnace in the economics of steel production. Concurrently with these new demands on the blast furnace, it has been found that the trend of production per furnace in this country has been downward because of the deterioration in raw material quality.

Republic has increased the top pressure of its 27-ft. hearth furnace at Cleveland from 2.5 to 12 p.s.ig. and the blast pressure from 21 to 30 p.s.ig. and, as a consequence, has been able to increase the wind blown from 80,000 to 115,000 c.f.m., the greatest wind volume ever blown into a blast furnace. Iron tonnages have been increased from an average of 1175 tons per day under normal operation in July 1946 to 1430 tons per day for two months in 1946-47; for the same periods coke rates have been decreased from 110 to 250 lb. per ton of iron and flue dust has been decreased from 40 to 70 lb. per ton of iron.

Republic Steel Corp. is proceeding with conversion of additional furnaces to pressure operation and has purchased the biggest blower ever built, 125,000 c.f.m., 40 p.s.ig., for use on the next pressure furnace. Several other steel companies, both in the United States and abroad, are planning conversions of blast furnaces to pressure operation. In short, it is believed that a new era of blast-furnace practice, involving high tonnages at low fuel consumption, is dawning as a result of the pioneering work of Republic Steel Corp. and Arthur D. Little, Inc.

Honorable Mention to Peters, Emerson, Nefflen, Harris & Cooter

C. G. Peters, W. B. Emerson, K. F. Nefflen, F. K. Harris and I. L. Cooter of the National Bureau of Standards receive the first Honorable Mention for their development of a new electrical process for drilling small diamond dies for wire-drawing, which shortens die-polishing time by 100 hr., increases die production 5-fold in some cases, and has resulted in the development of a fine-wire diamond die industry in this country for the first time in its history.

Prior to 1940, the indispensable small diamond dies were imported from Europe because labor costs made their manufacture unprofitable in this country. During the war, with all supplies from Europe cut off, the National Bureau of Standards undertook an investigation to speed up the manufacturing process and improve the quality of dies to meet the emergency requirements for many vital war products. Domestic production could not meet the war time requirement for critical small-size dies (0.004 to 0.0015 in.) which at that time was 30,000 per year, with a total value of $1,200,000.

The new electric drilling process developed by the Bureau replaces the older mechanical die cutting with high-voltage followed by electrolytic drilling.

Complete operations for making a die by electrical methods take 7 to 15 hr., depending on the type of die, with 10 hr. as an average for the process. Actual man-hours are considerably less than this, averaging about 2 man-hours per die, because almost every stage in the process is easily adaptable to multiple production. Dies produced by the National Bureau of Standards method have better wearing characteristics in service than those produced by purely mechanical methods.

The electrical method requires no special skills or long training on the part of operators. Equipment is inexpensive and the drilling technique is simple, making the work less tedious and more practical for small as well as large scale enterprise. The new method will reduce the production cost for small-size dies by more than one half. In addition, it will also cut the cost considerably for most other sizes. This is of major importance to industry since the total requirements for all diamond dies is 300,000 per year.

Honorable Mention to Thermex Division

The application of high-frequency heating to the edgebonding of wood products, resulting in savings as high as $22,680 per year for a single user, is the achievement that won for Thermex Division of Girdler Corp. an Honorable Mention Award. The fabricator in whose plant this work was done is the Red Lion Cabinet Co. of Red Lion, Pa., who now uses a high-speed, batch-type high frequency installation in place of two 40-section carrier clamps to bond 36-in. by 42-in. by 2-in. panels in as few as 12 sec., and the panels may be immediately dressed and used. By ordinary procedures at least 30 min. would have been required for satisfactory bonds and the panels could not be safely dressed for 8 to 9 hr.

In the manufacture of these particular products (Philco radio cabinets) savings included 66⅔% in production cost and manpower, 75% in floor area, and 75% in adhesive, and there were outstanding quality and comfort advantages as well. The savings brought about by Red Lion's high-frequency installation will pay for the Thermex unit spreader and press in considerably less than a year.

Honorable Mention to Westinghouse Motor Div.

The achievement that won for Westinghouse Electric Corporation's Motor Division at Buffalo an Honorable Mention Award was the complete breaking away from traditional electric motor design, materials and manufacturing processes to produce a line of integral motors (1 to 15 hp.) which provide required horsepower in a minimum size. High among the accomplishments is the ability to assemble about 28,800 different motor styles of each hp. rating from 126 basic parts as compared to 2,800 parts formerly required. The new motor is 35% smaller than its predecessor and has improved performance characteristics and appearance.

The result of this enlightened approach to the re-engineering of an accepted product was a motor which can be produced much faster than formerly, which does not require a huge foundry pattern inventory and which is much more economical of size and materials than conventional electric motors of the same size.

Here are some of the changes made:

All sand castings have been replaced by steel formed by rolling or drawing and assembled by automatic welding. Most of the welding is of the submerged-melt type. The welding machines and moving fixtures were designed by Westinghouse engineers specifically for this work.

All styles of a given motor size can be made from one welded, rolled-steel frame. This is the first application of all plate steel (no castings) to a complete line of motors other than fractional horsepower.

Although many factors prevent an accurate determination of the economic advantages of the new design and manufacturing methods, the user reaction to them has been definitely favorable. The reported failures of the new motors in service has been phenomenally low—much below the accepted average of failures.

Honorable Mention to Rigid-Tex

Rigid-Tex Corporation's Honorable-Mention-winning achievement was the development of sheet metal products that are design-strengthened to increase their rigidity and produce a patterned surface, which permit lowered material and fabricating costs and lighter weight of product.

Rigidized Metal is a product of a patented process whereby ferrous and nonferrous flat-rolled metals can be given a clear-through pattern. The metal is cold flowed into patterns having depth as well as horizontal pattern by a process in which the metal is scientifically distributed throughout the cross-section and away from the neutral axis—giving a patterned surface which produces marked beneficial changes in mechanical, textural and utility values.

The development and production of the Company's so-called Rigidized Metal has accomplished three major advancements contributing to increased production, lower cost manufactured products and new design conceptions not hitherto possible. These are:

(1) Attaining increased structural values from unreinforced ferrous and nonferrous metal sheet and strip which permits the use of lighter gage metal without bracing, thus lowering material and fabrication costs and effecting overall weight saving.

(2) Making possible the use of "sandwich" type laminated construction using sheet metal which permitted a new type of structural design where rigidity and structural strength must be achieved with minimum weight, with also the ability to provide maximum heat exchange or insulation area within the laminated structure.

(3) Contributing durability, beauty and mar-resistance to flat-rolled metal surfaces by "texturizing," thus broadening the utility of these metals and permitting their use where traction, diffused light deflection, or texture for eye appeal is a factor.

Honorable Mention to T. E. Eagan

Mr Eagan, Chief Metallurgist of Cooper-Bessemer Corp. at Grove City, Pa. received his Honorable Mention Award for the use of high strength cast iron (Meehanite) for Diesel engine crankshafts, with manufacturing labor economy of 40 to 50%, plus extra engineering advantages.

The materials engineering of the Diesel engine crankshaft represents the results of eleven years research by the Cooper-Bessemer Corp. in the field of high strength cast irons, produced by controlled cupola methods.

The metallurgy of the shaft exploits the various processes patented by the Meehanite Metal Corp., and successfully extends to the field of large, thick-section castings the principles enunciated by Flinn and Reese as a result of their work in acicular irons, performed in the research laboratories of the International Nickel Co.

The following facts about this particular crankshaft are noteworthy: The casting is 12½ ft. in length, has 9¾-in. dia. pins and journals and weighs 4,200 lb. It is one of a line of cast crankshafts now used in Cooper-Bessemer engines in regular production. It is produced in a cupola, and has a tensile strength of 65,000 to 75,000 psi. measured not by a standard A.S.T.M. arbitration test bar according to common foundry practice, but by a test bar cut from the center of a full diameter extension of the crankshaft itself.

This combination of advanced cast iron metallurgy and the results of stress analysis by strain gage measurement has produced a line of cast-iron crankshafts which can be substituted for forged steel crankshafts without change of dimensions. The American Bureau of Shipping has approved these crankshafts, when made to Cooper-Bessemer Specification M-65, for use in *direct* propulsion marine service. This approval was received in April this year. This seems to be the first time A.B.S. has approved cast crankshafts, produced by cupola methods, for direct propulsion marine service.

The cost of producing cast-iron crankshafts compared to the practice of "block forging" them results in an overall labor economy of 40 to 50%. In addition to labor economy, the cast-iron crankshaft enjoys certain engineering advantages over forged steel shafts, especially machinability at high hardness, insensitivity to notch effect and others.

The partially formed stainless steel can is inverted over the lower die on a hydraulic press.

The problem of necking-in the top of a stainless steel pail was solved by using hydraulic pressure to force the metal into the desired shape, using the female die as a sealing unit.

Hydraulic Forming of Stainless Steel

by **WILLIAM C. BRICE,** *General Supt., Milwaukee Works, International Harvester Co.*

STAINLESS STEEL OF THE "18:8" TYPE was decided upon for the pail of a milker unit by International Harvester Co. because of its excellent resistance to corrosion and its durability in service. The pail must withstand not only the action of milk acids, but the effects of the various cleaning compounds used daily in maintaining the equipment in sanitary conditions.

A one-piece pail, approximately 12 in. in dia. and 18 in. high, was required to be drawn from stainless steel. Complicating the problem was the fact that the design required that the top of the pail be necked in slightly. The grade of stainless steel decided upon was AISI 302, and no difficulty was encountered in the drawing of the cup. Developing the neck at the top of the pail, however, caused considerable trouble.

Hot spinning of the top of the pail was attempted first. The deep-drawn piece was heated, placed in a fixture in a roller lathe, and the top of the can was tapered in by the rotating rolls. It was found to be impossible to hold the dimensions as closely as was desired, and other methods of shaping the neck of the can were sought.

Rubber bulging, in which a rubber tool is placed inside the can and pressure applied to squeeze the can against the walls of a die, was given a trial. While this method is used successfully with small parts, the

The upper die provides a sealing action so the shell can be expanded inside the upper die by hydraulic pressure. Forming is completed in this step.

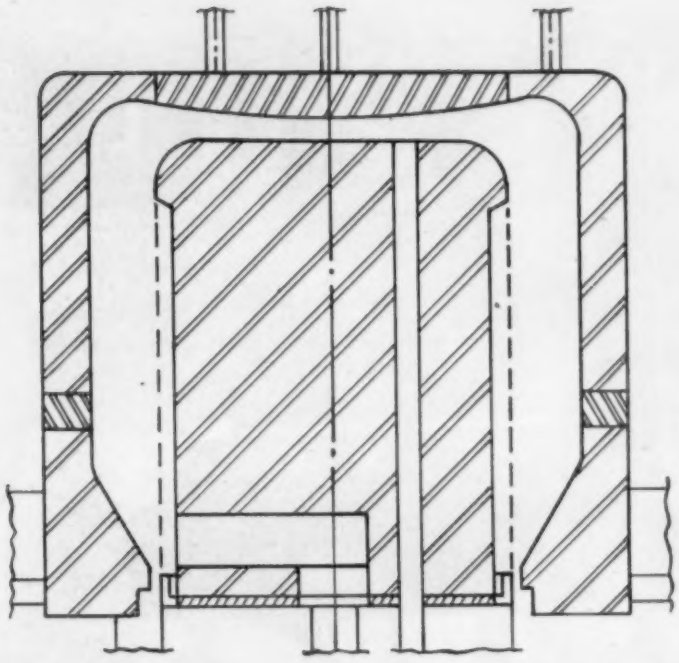
milk pail was found to be too large to give satisfactory forming within tolerances. The rubber bulging tool deteriorated rapidly under the high pressures required, and dimensions altered accordingly.

An attempt was next made to fill the pail with oil, seal over the space at the top around the ram of the press, and to expand the pail inside a die. This method gave satisfactory forming, but the leakage of oil was so great that the process had to be abandoned as a large-scale production procedure.

The method finally worked out, and giving satisfactory results, expands the pail with liquid pressure alone, without the use of the ram of the press. To avoid the loss of liquid, the pail is inverted at the time of expanding, and the liquid, held by gaskets and the press pressure during the work cycle, runs back into a storage receptacle after the pail has been formed.

The forming of the pail begins with the blanking of a disk of stainless steel from 0.040-in. sheet stock, fully annealed. The first draw forms a cup about 6⅝-in. deep and 17.650 in. in dia. A second draw, following immediately afterward, makes the piece 9⅝-in. deep and 14.536 in. in dia. This handling of the metal, by which the piece is reshaped rather than drawn, permits forming the deep cup that later becomes the pail without thinning the metal.

An anneal is required at this stage, and the cups



The dotted line shows shape of the can before hydraulic pressure is applied. The final shape conforms to that of the upper die.

are carefully washed to remove all traces of lubricating compound, so avoiding discoloration of the stainless steel from carbonization of the organic material during heating. The cups are heated to 1975 to 2000 F in a continuous furnace, then cooled in a blast of air to 900 F within 45 sec. to prevent deleterious metallurgical changes. After the cooling has been completed the cups are cleaned by pickling, using a mixture of nitric and hydrofluoric acids with inhibitors, to remove any oxide film that may have been formed at the annealing temperature.

In the third draw the workpiece is reshaped to a cup about 13¼ in. deep and 11.521 in. in dia. The fourth draw takes place at the same ram on the same press, immediately after the third, and gives the piece a depth of 17⅛ in. and a diameter of 9.144 in. The piece is now washed free of lubricant, annealed, and pickle cleaned as before. The flange is next formed at the top of the can, and the excess metal trimmed off.

The can is now ready for the hydraulic forming operation, in which the piece is given its final form. This step takes place in a hydraulic press, with a nonmating die connected to a bulging cylinder in which the liquid pressure is built up for the expansion of the can. The male portion of the die is the lower half, while the female half is attached to the ram of the press. The dies act merely to retain the liquid and to limit the expansion of the metal, and the expansive force is provided by the liquid.

Die Locates Work

The can, about 9 in. in dia., is inverted over the male die, a cylindrical piece that locates the work. A leather gasket is placed under the flange of the can to seal off the bottom, leather being used because the liquid used is a mixture of water and soluble oil. The ram, to which the female portion of the die is attached, seals off the neck of the can with the die serving as a holddown. The female die has the form of the pail in inverted position, and when closed holds the flange of the can against the leather gasket with a pressure of about 2300 psi.

For the forming operation, liquid is admitted to the space around the male die and inside the workpiece. The liquid is fed through an inlet pipe in the die from the pressure cylinder under the press, and a second pipe, opening from the top of the male die, provides an air outlet. This second pipe discharges through a spring valve that permits only air to escape. As the liquid fills the space between the inside of the can and the lower die it exerts a pressure outward and upward that expands the stainless steel until it reaches the walls of the female die. An expansive force of about 300 tons is used, and the pressure is maintained for about half a minute to permit the metal to set. A liquid return valve is then opened, and the liquid is drained off from an intake at the bottom of the male die, and returned to the bulging cylinder.

As a result of the hydraulic pressure applied, the side walls of the can have been expanded from a diameter of about 9 in. to about 12 in., and the depth has been decreased about 2 in. The bottom is given a concave surface for added rigidity.

Horizontally retractible sections of the upper die are withdrawn from the closed position after the completion of the hydraulic forming and return of the liquid to the pressure cylinder. The finished piece can then be removed from the press. The uniform application of pressure obtained by the hydraulic method, and the holding of that pressure, result in shaping the stainless steel pails with no appreciable spring-back. Variation in dimensions from piece to piece has been eliminated, and tolerances are met without difficulty. The tolerance for the pail diameter is +0.002 in. About 50 pieces are formed per hr.

The drawing operations are performed on the same press as the final forming, using different mating dies for each step. As a result the work returns to the same press, and the same furnace and washing and pickling equipment are used for the anneals between draws. A compact department with a minimum of machinery is thus obtained to perform the entire forming operation.

Polishing of the stainless steel pail, inside and out, is accomplished in another department. The external surfaces are ground on an abrasive wheel while the pail rotates, and a bright finish is obtained with little handwork. For the interior surfaces, where a very smooth finish is desired for sanitary reasons, the pail is filled with limestone chips and water, a cap is placed over the opening, and the loaded pail is revolved in a machine for about 24 hr. This treatment imparts a satin finish to the interior with no more handwork than is required to load and unload the pails at the beginning and end of the process.

Two different sizes of pails are made for various models of milking machines, a slightly larger one requiring five draws and two hydraulic expansions. The same principles, and the same press, are used for all operations, however.

Here Geon paste resin is used as a fabric coating. Application is by means of a laboratory knife coater.

Paste Forming Resin
Used for Coatings, Molding and Film Making

by **M. N. BURLESON,** *Development Engineer, B. F. Goodrich Chemical Co.*

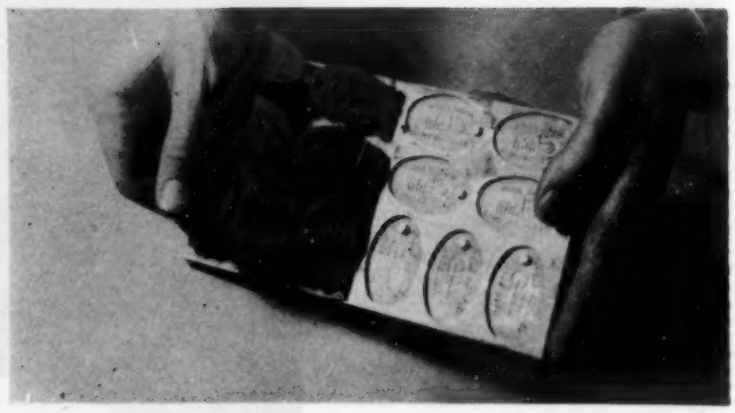
New Material Preview

Simple methods and equipment are used to apply the new paste-forming resins in low pressure and cast molding, and spread and dip coatings.

COATINGS, CERTAIN TYPES OF molding procedures, and film forming will soon have a new material especially intended for such procedures, and promising an excellent product with simplified methods and equipment. A polyvinyl chloride that can be made up as a paste with plasticizer, and without the use of water as a dispersing medium, as with latex, or with organic solvents, has undergone laboratory testing and semi-commercial use successfully, and is now available to industry under the name of Geon paste resin.

Latex coating with polyvinyl chlorides has used dispersions of very fine particles of the resin in water, with a plasticizer added, as the coating material. It is necessary to evaporate the water from this latex after application of the coating, and then to fuse the particles at about 300 F. Solution coating with

Molds are filled with a Geon paste resin formulation.



After fusion in an oven, molded pieces are easily removed from the simple molds.

the same resin has involved use of an organic solvent such as methyl-ethyl ketone along with the vinyl and the plasticizer, and evaporation of the solvent after the coating is laid down. Recovery of the solvent has always been a problem.

The new coating material uses only resin and plasticizer, with the resin dispersed in the latter ingredient to form a paste. There is nothing to evaporate in this formulation, and simple equipment and proper heat treatment are sufficient to produce an article possessing the same properties as that by the older dispersion methods. The paste resin takes advantage of the fact that solvation or plasticization of this vinyl is extremely slow at room temperature, and that the plasticizer can be used as a vehicle for the resin while such temperatures are maintained. Upon heating, the liquid plasticizer is absorbed by the resin, and a tough, flexible solid results.

In conventional processes where vinyls are calendered, extruded or molded, heat is necessary during at least two operations. The resin is first plasticized on a hot mill and then calendered by hot rolls or extruded through a hot die. In the paste system, heat is necessary once and must be sufficient to drive the plasticizer into the resin. This necessitates heating the mass to 325 to 350 F for the fluxing or fusion of the resin and plasticizer. The physical properties of the resultant articles are dependent on how successfully this heating process is completed. Since there is no chemical reaction involved, it means that the mass is simply brought to the desired temperature.

Geon paste resin is a free flowing white powder with a specific gravity of 1.40. Particle size ranges from 1 to 30 microns with a mean diameter of 8 to 10 microns. With proper wet or dry grinding, the agglomerates may be broken down to a 1 to 5 micron range, which is optimum for most paste formulations. In some cases, it may not be necessary to grind the resin at all.

Formulation

B. F. Goodrich Chemical Co. has available two Geon paste resins, one designated 100-X-26, the other 100-X-210. Both resins are applicable to two distinct paste formulating methods, the choice of each controlled by the desired properties in the finished product. The two resins differ principally in the degree of viscosity obtained with equivalent resin-plasticizer ratios. The properties of each are shown in Tables I and II.

The first of these formulating methods is concerned with a straight resin-plasticizer mixture, where the resin is merely dispersed in plasticizer by simple

Table I—Typical Properties of Geon 100-X-26 with Varying Amounts of Resin and Plasticizer

Geon 100-X-26	60	55	50	45	40	35
Dioctyl Phthalate	40	45	50	55	60	65
Hardness (After Fusion) Durometer A	70	60	50	40	30	20
*Initial Viscosity Centipoise	50,000	25,000	5,000	2,500	1,000	500

**A single reading taken with a Synchro-Lectric Viscosimeter*

Table II—Typical Properties of Geon 100-X-210 with Varying Amounts of Resin and Plasticizer

Geon 100-X-210	45	50	55	60	65	70
Dioctyl Phthalate	55	50	45	40	35	30
Hardness (After Fusion) Durometer A	50	55	65	70	80	90
*Initial Viscosity Centipoise	1,000	2,900	3,000	3,500	7,500	87,000

**A single reading taken with a Synchro-Lectric Viscosimeter*

stirring. The other involves the addition of a volatile diluent to the resin-plasticizer mixture. This latter method makes possible a wide range of hardness in finished products.

Paste formulation using the resin-plasticizer system is quite simple. The best dispersion is obtained by adding the resin to the plasticizer and, for some applications, this is accomplished by simply stirring. An ink mill employing only a few passes can also be used to give an excellent dispersion. Care must be exercised to cool the rolls. For coatings that are not subsequently embossed, it is advisable, if simple mixing is used, to dry-grind the resin. This grinding is not necessary for molding applications.

The choice of plasticizer is extremely important. A low viscosity and a slow rate of solvent action at room temperature, low temperature flexibility, volatility, odor, color, and compatibility are desirable. Recommended plasticizers are dioctyl phthalate, trioctyl phosphate and di-n-octyl phthalate. Blends of plasticizers such as dioctyl phthalate and triethylene glycol esters have proven useful in lowering the viscosity and reducing thixotropy.

Paste formulations employing a diluent are also relatively simple. The principal advantage of this system is that the diluent provides additional volume and retains fluidity during fabrication even with low plasticizer content, thus giving varying degrees of hardness in the finished product. Straight chain aliphatics just above the gasoline range in molecular weight are recommended as diluents because they do not swell the resin, thereby maintaining low viscosity and increased storage life. Small quantities of active solvents such as ketones and esters may be added to the mixture as an aid in stabilizing the mix. These ingredients also help in the fusing process by softening the resin for the plasticizer.

Like all organic material, Geon resin tends to decompose to some extent on exposure to high temperatures. Consideration should be given to the use of heat stabilizers such as SN or V-1-N with paste resins to reduce the possibility of heat breakdown during the fusion.

The choice of color pigments is generally governed by the stability of the shade with respect to heat and light. Colors that have been satisfactory for conventional Geon compounding also show good results with Geon paste resins. They are anthraquinone and indanthrene blues, yellows and orange; phthalocyanine blues and greens; and the cadmium and lithol reds. Fillers such as clay or whiting should have as low an oil absorption factor as possible. The maximum amount of plasticizer is then available for lubrication and dispersion of the resin. All pigments should be added to the paste mix as dispersions in plasticizer.

Applications

Applications for Geon paste resins cover the fields of low pressure and cast molding, spread and dip coating. On the basis of present trends, paste technology gives every indication of competing for and capturing a substantial part of the vinyl sheeting business. Solution coating requires expensive and dangerous solvents, and coatings have always required a great many passes through the coating machine. The new paste process permits laying down of films or coatings up to twenty mils thick in one operation. Therefore, the range of films that can be produced by paste processes can be varied to include thin films useful in good packaging, films of medium gage for raincoats, shower curtains, aprons, etc., and heavy films practical for upholstery and luggage.

Heretofore, in molding polyvinyl materials, it has been necessary to use either injection or compression molding machinery. Articles molded from Geon paste resin exhibit the same excellent service qualities as those obtained from conventional resins. Gaskets, shoe soling, printing rolls, toys and novelty items are a few of the articles that can be molded with this new low pressure technique. Geon paste formulations have shown promise in filling in voids in large electrical cables because they can be so readily forced into the interstices of cables and fused in place.

Using the resin-plasticizer formulation in dipping applications, it is possible to obtain a very thick coating with a single dip. Dipping is aided by preheating the article to be coated. The quantity of paste compound picked up by a dipped article can be controlled by the viscosity of the formulation and by the amount of heat added to the dipped part. Large potential volume is indicated for dipping with paste materials for such applications as gloves, toys, dish drainers, plating racks and thin-walled electrical insulations.

Table III—Advantages of a Paste Resin System

Resin-Plasticizer System	Resin-Plasticizer Diluent System
1. No solvents used	1. No retention of solvents
2. 100% total solids	2. High total solids
3. No shrinkage of mass due to loss of volatiles	3. Rapid release of diluent
4. Can be low pressure molded	4. Films of variable hardness can be produced
5. A thick coat can be applied with one dip or pass	5. Inexpensive diluent
6. Easy processing—no heavy equipment	6. Same as resin-plasticizer
7. No water used—eliminates shrinkage of fabrics	7. Same as resin-plasticizer
8. Can be wet sanded after mass had been set	8. Same as resin-plasticizer
9. Resultant fused mass has all the properties of regular Geon plastic; *i.e.*, tough, light in weight, weatherproof, chemically resistant and an unlimited color range	9. Same as resin-plasticizer
10. Use of straight polyvinyl chloride polymer	10. Same as resin-plasticizer
11. With adequate heat, present equipment may be used.	11. Same as resin-plasticizer
12. No calender grain	12. Same as resin-plasticizer
13. No residual strain	13. Same as resin-plasticizer
14. Excellent reproduction of casting surface	14. Same as resin-plasticizer
15. Good production speed	15. Same as resin-plasticizer

Here are a few examples of how automotive engineers use service requirements of parts as a means of selecting materials and the methods for fabricating them.

Materials and Their Requirements for Automobile Stampings, Bumpers and Pistons

by **NELSON G. MEAGLEY,** *Assistant Chief Metallurgist, Willys-Overland Motors, Inc.*

THE AUTOMOTIVE FIELD GENERALLY has been a leader in selecting and applying materials. Each part of a modern truck or automobile has to be studied carefully to determine the fabricating and service requirements. After requirements are determined there comes the job of selecting materials that most nearly meet these needs.

In this article, the author has chosen three groups of automotive parts as typifying the service requirement and materials selection problems of automobile components, discussing the general requirements, typical types of failure and the materials used.

Stampings

The usual requirement of a metal used for a stamping or pressing is its ability to deform in the press without tearing or leaving objectionable surface markings. The following additional requirements are specified in special cases.

A. When a part is highly stressed, tensile strength higher than is obtainable in low carbon steel is needed. Strength under severe vibrations is often of great importance.

B. When high finish is required, the surface quality must be suitable to obtain this at reasonable cost.

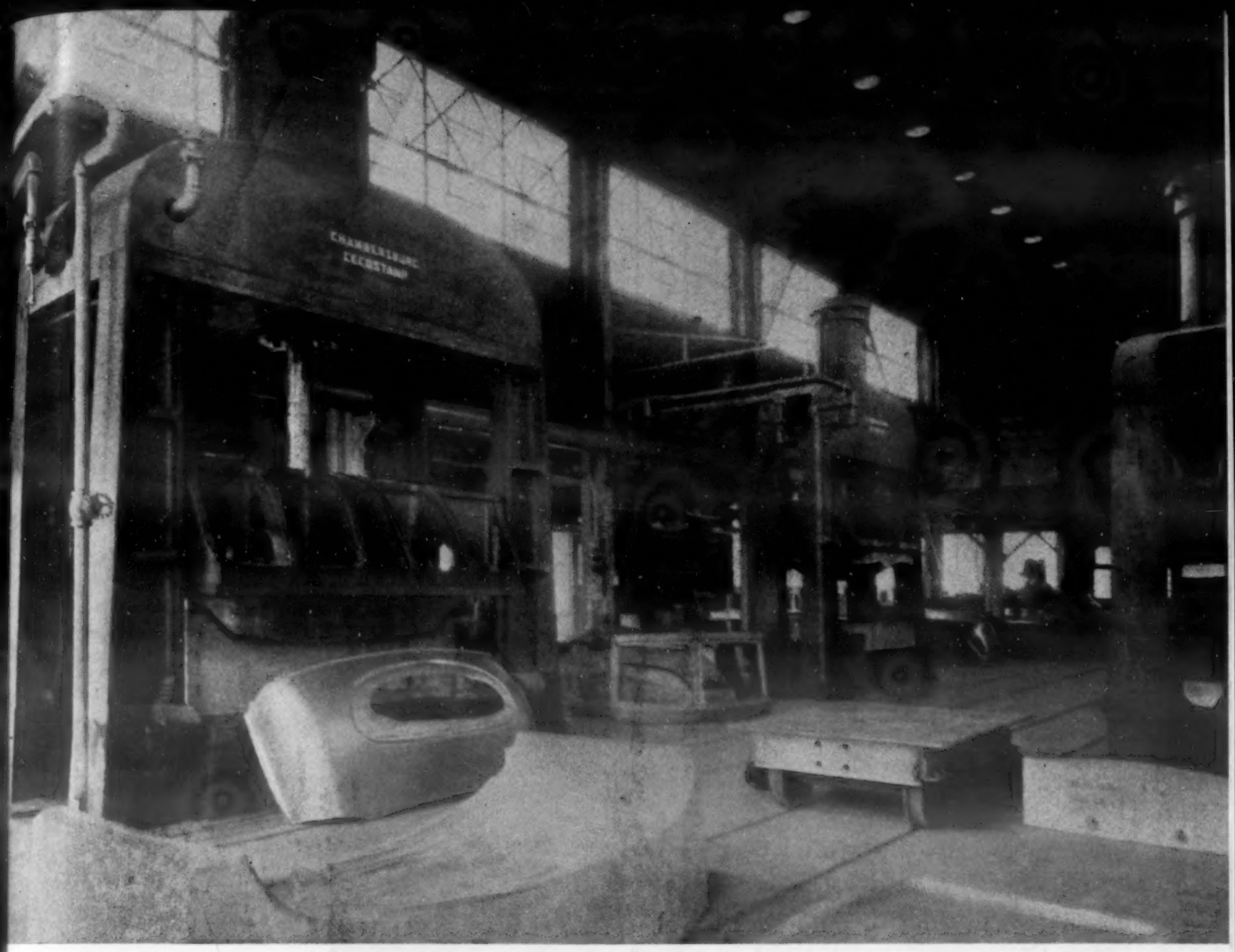
C. Corrosion resistance.

Stampings fail by bending under impact, fracture through fatigue, tearing under static stress (especially around holes) and through corrosion.

Automotive stampings in the United States are almost exclusively made from steel. Whether it is strip or sheet steel depends upon the size; whether cold rolled or hot rolled, depends upon surface finish or uniformity of gage desired. An exception to this is found in some large commercial vehicles where weight reduction from the use of aluminum or magnesium warrants the extra cost of these materials. In European cars there is a noticeable trend in the use of aluminum for stressed skin type of construction.

The following applications are characteristic of the use of steel for automotive stampings.

1. For general stampings lighter than 6 U.S.S. gage (0.1943) where service stresses are low and deformation of the stock in stamping is not severe—open



Every automobile, bus and truck utilizes many stampings of all shapes and sizes. Shape, size and service all have some bearing on the material selected. (Courtesy: ACF-Brill Motors)

hearth process steel, 0.08 to 0.13 carbon.

When the part is subjected to vibration or shock the grain flow is also specified. This should be parallel to the flow lines of the stress.

Cold rolled is specified in gages lighter than 18, where uniformity of gage is required, or where a high finish is needed, such as on passenger car exterior surfaces. Hot rolled is lower in price and is generally suitable for all other applications.

2. For stampings requiring some drawing but not so severe as to warrant price extra for deep drawing quality—open hearth quality steel, 0.10 (max.) carbon.

The rules given in No. 1 for grain flow and surface finish also apply to this specification.

3. For stampings of a structural nature where the maximum strength in the material is desired without paying a price extra for special grade—open hearth quality steel: 0.18 to 0.23 carbon (suitable when deformation in stamping is limited to simple bends with radius equal to minimum of metal gage); 0.10 to 0.15 carbon (suitable for stampings more suitable than above, but do not specify for deep drawing).

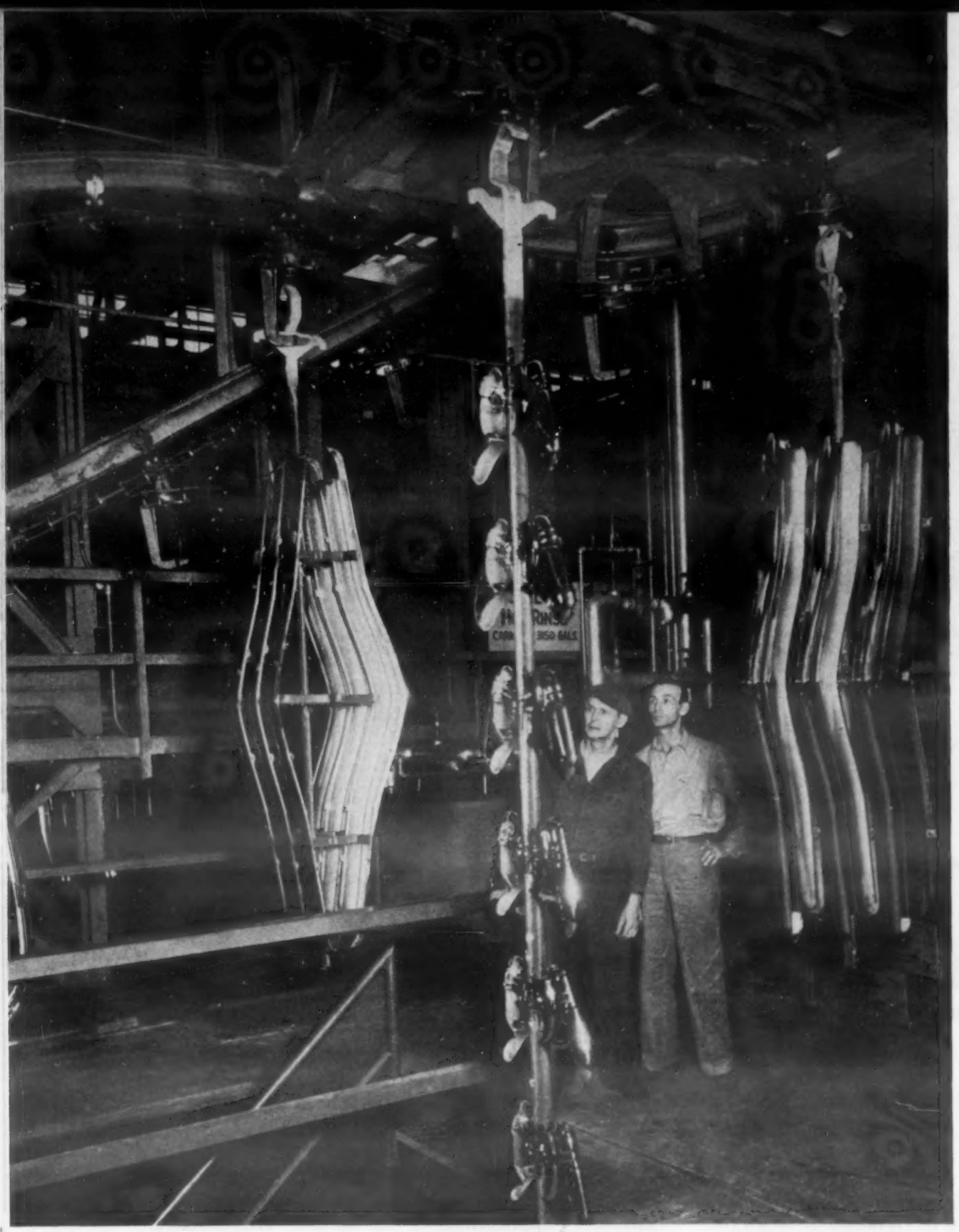
High tensile-low alloy steels are specified for some heavy-duty applications of this nature. This material will give 50,000 PSI yield strength and will generally have corrosion resistance in atmosphere of two or three times that obtained in standard steels.

4. For stampings requiring deep drawing quality—open hearth process steel, 0.10 (max.) carbon. Carbon quality must be suitable to form the part satisfactorily.

This grade of steel carries a price extra and is tailor made for the drawing problems of that particular part. Breakage in the dies above a reasonable amount is replaced by the mill. Deep drawing sheet or strip is generally not handled by steel warehouses for the above reason, and is only obtainable direct from the mill.

Bumpers

Bumper assemblies comprise two parts, the bumper bar and the bumper arms. The bar is required to take the shock of minor impacts and transmit this through the arms to the chassis without damage to any part of the vehicle. On commercial cars and trucks a neat



Automotive bumpers serve both decorative and protective functions. The material selected must be spring-like, easily formed and able to take a high finish. (Courtesy: The George Nankervis Co.)

functional member is generally suitable while on passenger cars the bumpers have decorative requirements in addition to the engineering application.

Bumper failures usually occur through:

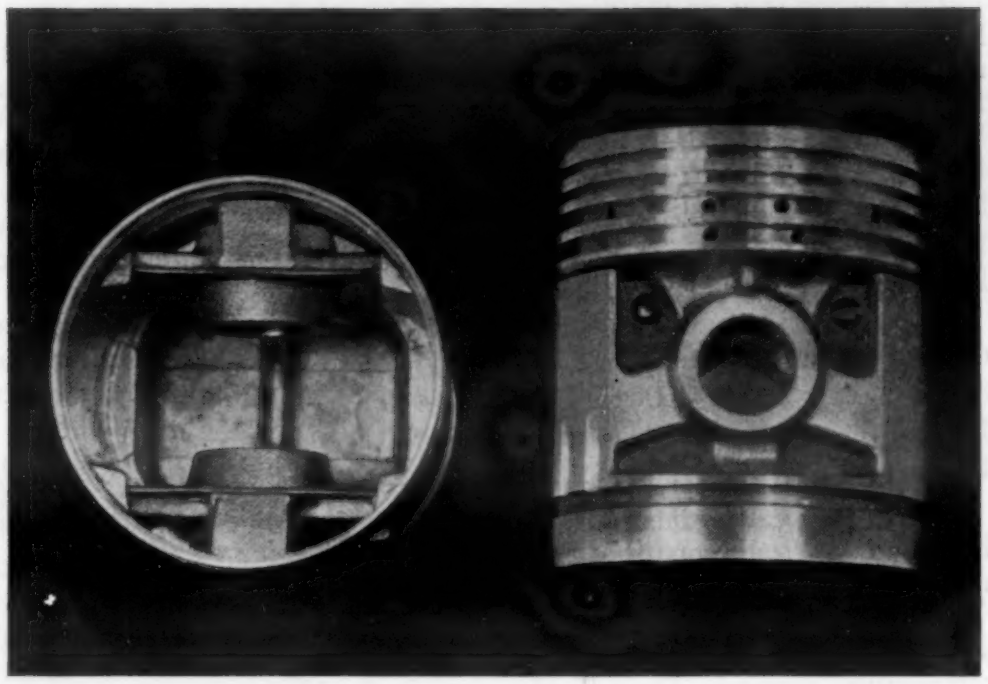
1. Bending of the bumper from collision.
2. Corrosion or peeling of the plating.
3. Breakage of bolts fastening bumper bar and bumper arm.

Conventional passenger car bumpers are made from spring steel and must be formed hot. The bumpers are then heat treated and finally finished by chromium plating. Extensive preparation of these hot worked surfaces is required to obtain a satisfactory plated finish.

Commercial vehicle bumpers are generally made from 0.20 carbon H.R. strip formed into a deep channel so as to give a high sectional modulus. The high modulus provides the necessary strength and spring action. These bumpers are finished by painting. Many trucks now use passenger car bumpers.

Conventional passenger car bumpers are also of rather simple design. Spring action and strength is obtained by using heat-treated high carbon steel, generally A.I.S.I., C-1085, with the bumper bar tempered to B.H.N. 269 to 321 and the bumper arms to B.H.N. 321 to 375.

Considerable attention has been given to the use of new heat treating developments so as to reduce the cost of surface preparation prior to plating. It is claimed that Martempering bumpers hot formed from A.I.S.I., C-1040 will give physicals equal or better than from C-1085 hardened in conventional cycles and



Materials used for pistons range from cast iron, through steel and aluminum alloys. The pistons shown here are of aluminum alloy produced as permanent mold castings.

the heat damage to the surface is a minimum. Cycles are as follows:—

(A) Anneal, or use as forged.
(B) Pickle.
(C) Heat in salt for hardening.
(D) Quench in salt (Martemper).
(E) Pickle about 30 sec.
(F) Plate.

One manufacturer is using A.I.S.I., C-1046 spheroidized annealed. This structure permits cold forming and there is sufficient carbon to heat treat to the required hardness. Present passenger car practice tends toward elaborate bumper bar design, some of welded three-piece wrap-around construction. These members cannot be economically made by hot forming spring steel, and material must be used having good cold forming properties in addition to weldability. Low alloy, high yield (50,000 psi.) steels are generally used and the additional strength required for proper bumper action is obtained through the higher sectional modulus of the more elaborate design.

All passenger car bumpers are chromium plated. Present practice tends toward increasing the thickness of the copper and nickel undercoat of this plating and, although specifications differ among the various automobile producers, the A.S.T.M. type F.S. is typical. This requires nickel plus copper coat of 0.00125 in., and at least 0.0006 of this must be nickel. A chromium flash of 0.00001 in. is placed on top to prevent the nickel from tarnishing. Bumpers properly plated to this specification will hold up in excess of 72 hr. in an A.S.T.M. salt spray cabinet.

Consideration has been given to other materials for bumpers. Stainless steel, although higher in cost, can be made into bumpers having corrosion resistance for the full life of the vehicle. This material will not chip, peel or flake, and scratches and gouging is easily repaired. Jessop Steel has applied 10% stainless clad type 302 on a mild steel backing for bumpers, and this material is deep drawn in the same dies previously used for other steels.

Plastics, reinforced with fiberglass, have been formed into experimental bumpers and both strength and cost are said to be comparable with steel. Weight is reduced. Pigmented resin molded into the surface eliminates paint so as to give a perpetual life.

Pistons

In an automobile engine, pistons serve as a movable wall of the combustion chamber so as to take the thrust of the explosion, transferring it through the connecting rod to the crankshaft. Efficient, long life operation requires the following:

1. The combustion chamber must be sealed from the crankcase so as to prevent blow-by of the explosion.
2. The frictional drag of the moving piston must be low so as to prevent wear.
3. Consideration must be given to the transfer of heat from the piston to the cylinder wall.
4. The piston must be strong enough to take the thrust of the explosion without damage. (500 psi. momentary values.)
5. Weight must be held to a minimum, since the action is reciprocating and inertia loss is considerable.

Pistons can fail by fatigue, wear, breakage, burning, or seizing. Material and design are inter-related to a high degree and become very complicated. Material or design changes should always first be proved by dynamometer tests.

Up until 1914 gray iron was the standard piston material and is still widely used. The desire to reduce the weight of these reciprocating parts led to wide experimenting with aluminum. Considerable difficulty was experienced at first due to the difference in expansion between aluminum and cast iron, causing either a loose fit with blow-by and lack of ring pressure at low temperatures or high areas or seizure at high temperatures. This problem has now largely been eliminated by improved design and low expansion alloy.

The hottest spot on the piston is the center of the head and from this point out a slight drop occurs to the side of the head. Most of the heat is transferred from the piston to the cylinder wall through the ring belt so that a rapid drop in temperature takes place in this zone. From the bottom of the ring belt to the bottom of the skirt an additional reduction in temperatures is found. The following are expected temperatures under full load conditions:

	Cast Iron	*Aluminum*
Center of head	800 to 850 F	500 F
Side of head	500 to 550 F	450 F
Bottom of ring belt	300 to 325 F	300 F
Bottom of skirt	250 to 275 F	225 to 250 F

Values for steel pistons are not available but it can be assumed from conductivity considerations that these are between those for cast iron and aluminum.

Cast Iron Pistons—These pistons have low expansion rates, good wearing properties and good high temperature strength. Their disadvantage is the high weight to strength ratio. S.A.E.-111 alloy is typical of the material used. This is a 30,000 psi. iron with hardness of BHN. 170 to 223, and is similar to that used in the block. The dimensions, and, therefore, weight of small size pistons are determined by foundry limitations in casting thicknesses. This is especially true in the skirt.

Steel Pistons—Steel pistons have high strength to weight at operating temperatures together with a coefficient of thermo expansion (0.000005), only half that of aluminum. Wear resistance is probably less than iron or aluminum. Ford has used steel pistons in large numbers. These are alloy castings having the following chemistry: 1.35-1.70 C, 0.60-1.00 Mn, 0.90-1.30 Si, 0.08 max. S, 0.10 max. P, 0.15-0.20 Cr, and 2.50-3.00 Cu.

As cast, the steel is hard and brittle and must first be heat treated. Cycles are reported as follows:

1. Heat to 1650 F. Hold 20 min.
2. Air cool to 1200 F. Hold 20 min.
3. Reheat to 1400 F. Hold 1 hr.
4. Furnace cool to 1000 F in 1 hr.

Following these cycles the hardness ranges from BHN. 207 to 241.

Aluminum Pistons—The advantages of aluminum pistons is their low weight, high thermo-conductivity (five times that of cast iron) and good wearing properties. Originally, their high thermo expansion caused design difficulties. Special alloys have been developed to reduce these and it is no longer considered a serious problem. Aluminum has low strength at high temperatures and pistons in racing cars sometimes collapse through over-heating. Aluminum alloys for pistons usually contain a small amount of magnesium, which improved bearing properties. Silicon is added to reduce the coefficient of thermo expansion. Values for this relationship are as below:

Aluminum Alloy	*Thermo Expansion*
S.A.E.-34 (1% silicon)	0.0000124
Y Alloy (English)	0.0000122
S.A.E.-321 (12% silicon)	0.0000106
(20% silicon)	0.0000100

S.A.E.-Alloy 34 has excellent high temperature properties, cast successfully in permanent molds, and has good resistance to wear. This alloy was formerly widely used for automotive pistons, although the present trend is toward S.A.E.-321, the low expansion alloy.

S.A.E.-321 is generally cast in permanent molds although sand casting with this alloy is practical, with lower physical properties. Tensile strength on separately cast test specimens is 31,000 psi. when aged for stabilization of dimensions and properties at operating temperatures. This strength can be raised to 40,000 psi. when the stabilization is combined with a solution treatment.

One disadvantage of this alloy is poor machinability, due to the formation of aluminum silicide; and carbide tooling is generally used.

Permanent Mold Castings—The advantages of permanent mold over sand methods of casting pistons are: (1) improved mechanical properties, (2) increased uniformity, (3) increased production, (4) smoother surface, (5) soundness and precision, (6) thinner sections possible, (7) dense fine grain from rapid cooling, and (8) progressive solidification methods are practical.

Disadvantages are: (1) difficult to drive off mold gases, and (2) restriction to contraction may cause cracks.

Additional sources of trouble, some of which are found in other casting methods as well, are:

(1) High solidification shrinkage takes place over narrow temperature range. Hot tears can result.

(2) Oxygen can enter due to its entrapment in dipping.

(3) Fast pouring agitates impurities and entraps them in mold.

(4) Slow pouring permits bottom metal to cool before top is poured and inferior castings result.

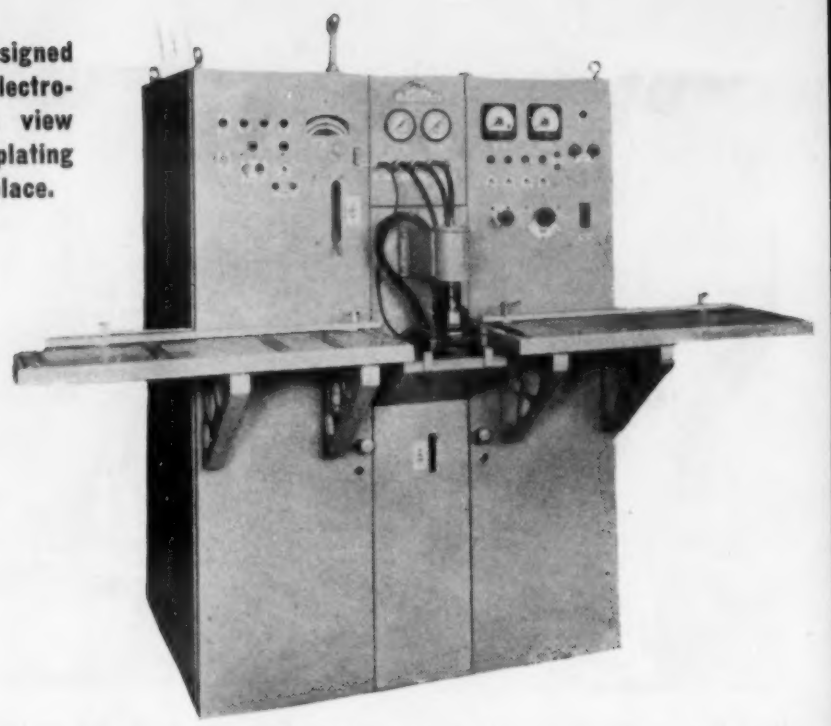
The castings are removed from the mold at Chrysler at 850 to 900 F. This is 70 sec. after pouring.

Following casting, the following treatment is given: Aging—400 F—6 hr. An increase in size occurs and this prevents growth in operation. The specifications require that additional aging for 10 hr. at 390 F shall not cause growth of more than 0.001 in. in any direction.

Hardness after casting and air cooling is 100 to 110 BHN. After aging this is increased to 122 to 130 BHN. Additional aging would again drop the hardness.

Composite Pistons—Much of the blow-by in worn pistons occur around the ring on the piston side. Attempts to reduce the wear at this point have been made by the use of a hard ring carrier. In Germany Ni-resist, having a coefficient of expansion similar to aluminum, has been used. In the United States Alcoa markets a hard ring carrier of aluminum bronze (90 copper, 10 aluminum).

In England a piston has been marketed which includes a steel wire to bind the piston. This has also been recently marketed in U.S. with the wire cast integral with the piston. Wire size is about 0.040 in. in dia.



This machine is designed for high-speed electroplating. In this view conveyors and plating fixture are in place.

Machine Designed for High-Speed Metal Plating

by A. D. CANNER, C. TWELE & T. J. CONNOR, *General Electric Co., Philadelphia, Pa.*

IN RECENT YEARS THERE HAS BEEN an urgent need for a new method of electroplating metallic coatings on metal parts in a manner that would eliminate many of the operations and hazards encountered by the use of the conventional tank method, and would provide for apparatus which could be used in the production line rather than handling and transporting the parts from a remote location.

Some 40 years ago, Dr. W. D. Bancroft pointed the way toward this goal by noting that "If a given solution will give a good deposit at any current density, it will give a good deposit at any higher density, provided the conditions at the cathode surface are kept constant."

Keeping cathode conditions constant can be accomplished in two ways, both of which have been long in use. One method is by cathode movement and the other by solution agitation. The difference in the commonly used agitation methods and the modern method is in the relative magnitude of solution velocities.

Conventional methods employ solution velocities (or the equivalent in cathode agitation) ranging from 1 to 10 ft. per sec. With no change in bath composition, velocities of 100 ft. per sec. can be used to produce, with correspondingly high current densities, very good deposits.

It is apparent, then, that for high-speed production all surfaces to be plated should be exposed to the rapidly moving solution. Those parts containing recesses which will impede the velocity of the solution will accordingly limit the current density that can be satisfactorily applied.

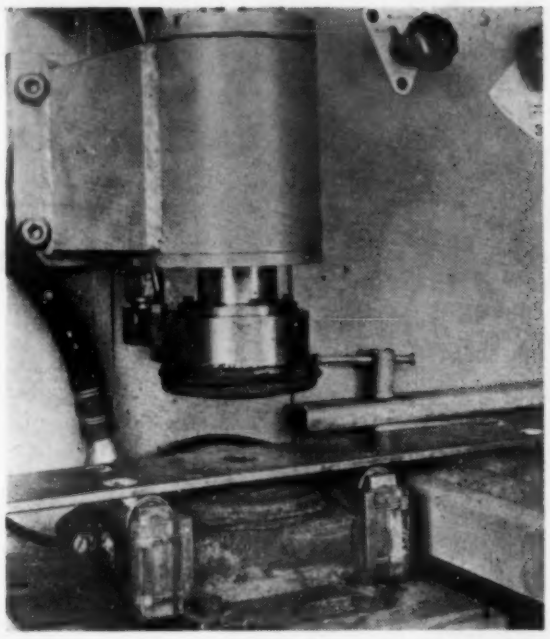
Any of the commonly used alkaline plating solutions that can be contained in steel equipment can be effectively utilized for high-speed plating procedure. Corrosive, acidified salt solutions would naturally require special construction materials.

Apparatus has now been developed, and is in service at G.E's Philadelphia plant, which by taking advantage of the foregoing phenomena, satisfies all the requirements necessary to accomplish this type of work with safety and a minimum of time. It eliminates the use of large tanks, acids, and motor generator sets. It also saves floor space, handling time and transportation of the product.

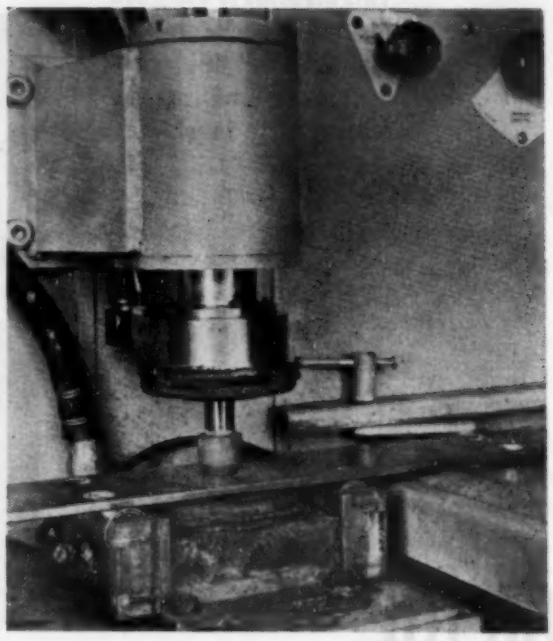
The cycle of operations has been accelerated to a point wherein seconds compare with hours when the conventional tank method is used. The apparatus takes the form of a packaged unit about 5 ft. wide, 4 ft. deep and approximately 5 ft. high, and requires service connections of 440 volt a. c. current, air at 100-lb. pressure, water at 50 lb., and a sewer connection.

The machine itself consists of a steel cabinet with all controls mounted on two front doors, which can be opened for inspection and adjustment, and a bracket placed at a convenient point to receive the various plating fixtures required to carry on this type of work and localize the plated surface. The fixtures also hold the work so that the plating solution is channeled over the surface of the part and returned to the tank, and to insulate the part from the machine proper which causes the work piece to act as the cathode and the machine as the anode.

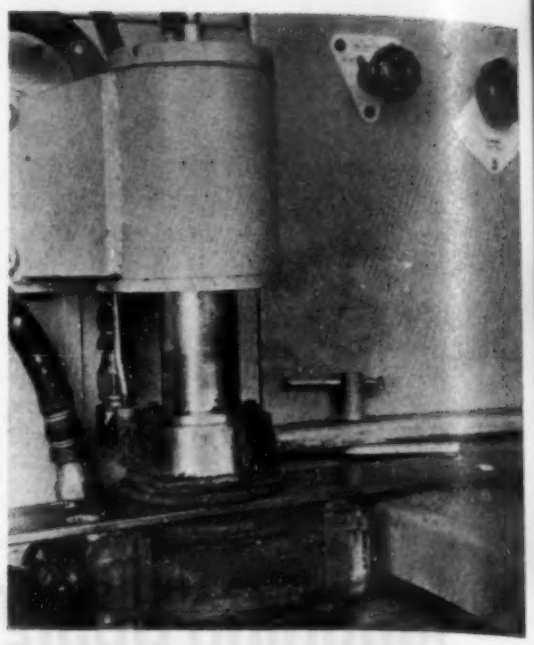
Thus, the apparatus offers a basic unit in which solution velocities reach 100 ft. per sec. and where high current densities are available. The solution is pumped continuously, by air pressure, through a motorized valve which controls the duration of flow through a suitable timer as required, and is returned to the solution tank by gravity. Fresh water is pro-



Here the plating fixture is open with work in place.



With the plating fixture in place and open, the work locator is in place.



Now the plating fixture is closed ready for plating.

vided, under pressure, to rinse all traces of the solution after plating has been accomplished and which is channeled to the sewer by the motorized valve. This provides that any work piece which is chemically clean and can be properly sealed off can be plated satisfactorily. As plating progresses, the elements in the solution are exhausted and must be replenished. Therefore, provision has been made for deposition of anode metal into the solution. Chemical characteristics are controlled through the conventional method and frequent samples.

All of the functions of the machine are carefully interlocked to prevent the flow of any solution while the fixture is open. Also, a 3-sec. time interval when the initiating button is pressed reduces hazard to the operator if leaks should occur in the seal after the cycle has been started.

Several of these machines are now in operation and have proven that high-speed plating is actually from 180 to 240 times faster than the conventional method and offers a type of equipment which can be used to a decided advantage in the production line.

General Description

The inclosing cabinet of the machine consists of a rectangular angle iron frame to which the side and top sheets are attached. A means of access to the interior is provided by double doors on the front and back, both equipped with locks to safeguard internal adjustments. The front doors have false panels attached to the inner surface on which the various electrical control relays and instruments are attached to facilitate repairs and inspection.

The machine can be operated with these doors open. The center panel between the front doors carries a fixture-holding plate or knee, with an inlet and outlet channel for conducting fluid to and from the fixture mounted thereon, and is provided with an inclosing basin to drain any excess drip back to the solution tank. This center panel also carries quick acting hose connections which conduct air pressure to the various fixtures that may be attached to the knee. The work conveyors can be detached quickly since they are attached by bayonet locks.

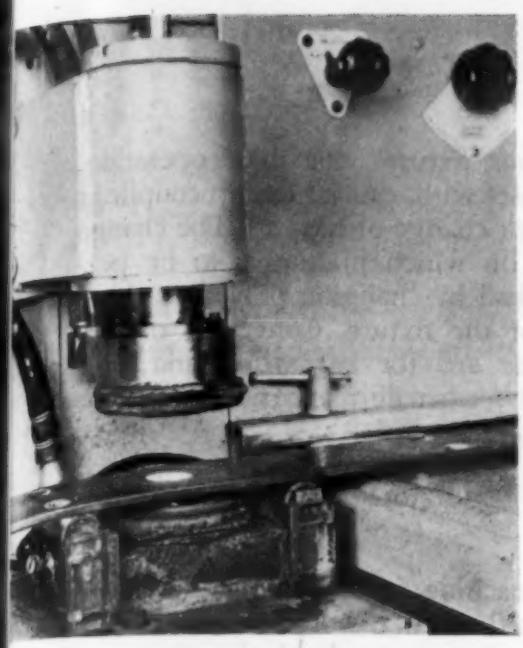
A work shield is attached to the front of this machine to protect the operator. The pressure tanks are bolted directly to the gravity tank, which rests on supporting angles on the frame, providing for their removal for cleaning and inspection. Brackets on the upper part of the frame work support the three solenoid operated air valves and the exhaust fan.

One of the features which make high-speed plating possible is the rate at which the plating fluid is passed across the work. The plating time is reduced by the high current and velocity of the solution. In this apparatus, air pressure on the fluid is used as a medium to force it across the work as the fluid is alkaline; a mechanical pump is not suitable for this purpose.

The pressure unit consists of an open rectangular tank partitioned off for plating solution at one end and a smaller compartment for water at the other. The pressure tanks, two for the plating solution and one for water, are bolted to the underside of the gravity tank and are covered by a valve unit which allows the fluid to fall by gravity, through a check valve, into the pressure tank below when it is not under pressure.

This feature provides a continuous flow of plating solution from the two pressure tanks, as each one is alternately allowed to fill by gravity while the other is under pressure, forcing solution past the work and returning by gravity to the upper tank. The control of this feature is accomplished by introducing an insulated steel rod through the pressure tank and which does not quite reach the bottom of the tank.

The control circuit flows through the rod, fluid and various relays to energize a solenoid-operated three-way air valve and allows air pressure to be applied to the tank which is full. As soon as the level of the fluid in the tank, which is under pressure, reaches the end of the control rod, the circuit is broken.



The plating fixture is reopened, showing a ring of silver deposited around the bolt hole.

As best results are obtained by heating the solution, heating units are installed in the gravity tank which are controlled by an adjustable thermal cutout, and as the heating of the fluid causes some evaporation, an insulated indicating rod is provided to automatically shut off the heaters and warn the operator, through a pilot light on the front of the cabinet, that solution or water should be added.

The chemical control of the solution is a laboratory function.

The water tank, which is used for rinsing solution from the work, operates in a similar manner as the solution tanks, with the exception that the level of the water in the gravity tank is controlled by a ball float valve and is replenished after each operation. The flow of water under pressure is controlled by an adjustable timer.

This method of pumping the rinse water through the apparatus is used because many municipalities do not allow water to be piped directly to the circuit.

Fluid Control Unit

This unit consists of a five-port, poppet-type, motor-operated valve of special design to allow the plating solution to flow through the plating fixture and fall by gravity to the solution tank, allowing the plating solution to drain by gravity back to the solution tank and the rinsing water to fall by gravity into the sewers.

The action of this valve is electrically controlled through adjustable timers for each function. The plating timer is mounted in the front door, and can be adjusted by the operator to meet the thickness of metal deposited on the work. The timers for drain and rinse time are mounted on the inside of the front door, and are adjusted to suit conditions, thus providing a predetermined value for a given operation. They are not adjustable from outside the cabinet.

This control valve is bolted directly to the knee which supports the plating fixture on the outside of the cabinet and through which the fluid flows. It can be readily removed for inspection and repair. Rubber seals are used throughout the apparatus where metal surfaces form a joint to eliminate the conventional gasket material.

The value of plating current varies with the area to be plated, and as the machine for silver plating of comparatively small areas is presented, selenium rectifiers with a capacity of 50 amp. are used as a source of current which can be increased to suit requirements.

The machine requires a source of 440-v. a.c. current which enters through a main switch on the front door to the transformers for 110-v. cycle timing circuit and the 12-v. solution level control, and goes also to the rectifiers for plating current.

The plating current flows through the solution and completes the circuit by a connection with the work. The duration of the plating cycle is controlled by a timer on the front of the cabinet, the value of which is adjustable in seconds up to 5 min. The current strength is read directly from the volt and ammeter, and the value may be changed through a Variac from the front of the cabinet.

On the face of the right hand front door are the circuit closing switches and pilot lights for control of the water pressure, the plating solution pressure, the solution heaters and the plating current. All circuits are fused to eliminate damage to other apparatus. On the left hand door is the plating timer, the control circuit switch which initiates operation control, the solution pressure *"On"* and *"Off"* switch which applies air pressure to the tanks, an emergency button which will clear the operating cycle quickly, thus resetting the operating cycle in starting position, and the starting switch for the operation cycle. Three indicating lights show what portion of the cycle is in operation, *viz.,* plating, draining and rinsing.

Plating Solution Replenishing Unit

As metal is deposited on the work, the plating solution becomes depleted, and to provide for continuous operation, some metal must be replaced. This feature of replacement is accomplished by using a porous ceramic cup suspended into the solution in the gravity tank which contains a potassium cyanide solution. This cup also contains a steel cathode suspended in the solution in the cup.

An anode, of the metal to be deposited, is placed on the outside and near the cup to complete the apparatus. A current selecting switch is placed on the front of the right hand door, which controls either plating current or replenishing current. Replenishing current strength is controlled by the Variac, as in the plating current. To replenish the solution in the gravity tank, it is necessary to bring all of the solution from the pressure tanks up into the gravity tank. This is brought about by closing two plug valves in the drain hole from the upper to the lower tank by turning the valve lever on the lower front panel down.

All of the solution is then blown through the plating fixture to the upper tank and will cease just as soon as the control rods in the lower tanks have lost contact with the fluid in them. The pressure tanks

will be filled with solution and ready for operation when the air valve lever is placed in top position. Air and solution pressure is indicated by the gages in the top of the center panel.

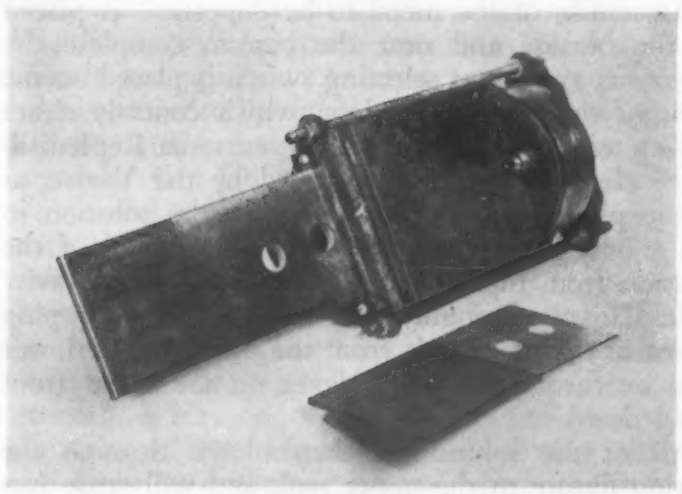
Plating Fixtures

In order to perform the operation of electroplating with this type of machine, it is necessary to confine the flow of the fluid to a given area, also to insulate the work from the rest of the machine. Many applications have been made for different types of work, *i.e.,* the plating of contact surfaces around bolt holes in copper bus bars, plating both sides at one time, the plating of the entire end of copper bars up to ⅜ in. thick and 4 in. wide for a distance of 5 in., the plating of spherical ends of copper contact studs as a last operation before stocking, and the plating of internal surfaces of copper tubes either for the entire length or a localized band of silver on the inner surface.

One fixture attached to the machine is designed for plating both sides of a copper bar into which a bolt hole has been made. The method of sealing off the area to be plated, in this case, is provided with a rubber sealing ring in the lower part of the fixture and the upper plunger. These seals are brought to bear upon the work through air pressure and also insulate the work from the machine proper.

The air valve lever in the left hand door controls the action of the plunger in the upper part of the fixture to either opened or closed position, and is interlocked to prevent opening the fixture while the plating or rinsing fluid is flowing through it. On each side of the lower part of the fixture is an insulated roller on which the work rests and makes contact, thus completing the plating circuit.

A method of locating the work in its proper position consists of a conical pointed plunger installed in the center of the work sealing plunger. Operated by a push button on the front panel, this locating plunger retracts when the fixture is closed and the push button has been released. Air is conducted to the various fixtures, for their operation, through flexible hose with quick acting couplings to provide for a quick change of fixtures. The change in area dimensions on which plating is to be performed is accomplished by changing only the rubber seals in the body of the fixture. Conveyors on the face of the machine are for bar work, and may readily be removed for small work which can be handled in boxes, etc.



This fixture shown here is used for plating the end of a bar. A sample of finished work is shown.

Operating Cycle

To prepare the machine for operation, the main switch is first closed and the individual circuit switches which control water and solution pressure, solution heater and plating current are then closed, being sure that the current selecting switch is in plating position.

Pilot lights to each respective circuit glow, showing that the circuit is complete. Closing control circuit switch on the left hand door sets the operating cycle circuit and closing push button switch on plating solution and the machine sets the machine for operation. The plating timer is adjusted for the proper duration of the plating cycle, and the area to be plated is cleaned with fine sand paper or emery cloth. Hands cannot come in contact with the cleaned surface, as oil from them will stop the plating action and cause it to peel.

After raising the lever to open the fixture, the work is placed in an approximate central location on the fixture and the locating plunger button, which will then come into operation and locate the work in its exact position, is pressed. The fixture is closed and everything is in readiness to begin plating. If leaks occur as the control button is depressed, they will automatically cease upon releasing the button. If leaks occur after the plating cycle has locked in, an emergency button immediately clears the cycle. The plating cycle will continue until all functions of plating, draining and rinsing are complete, when the button will light up showing that the cycle is complete.

Solution will not flow as long as the fixture is open, since a pressure switch is placed in the pressure line to the operating plunger and will not close the circuit until pressure has been applied to the work.

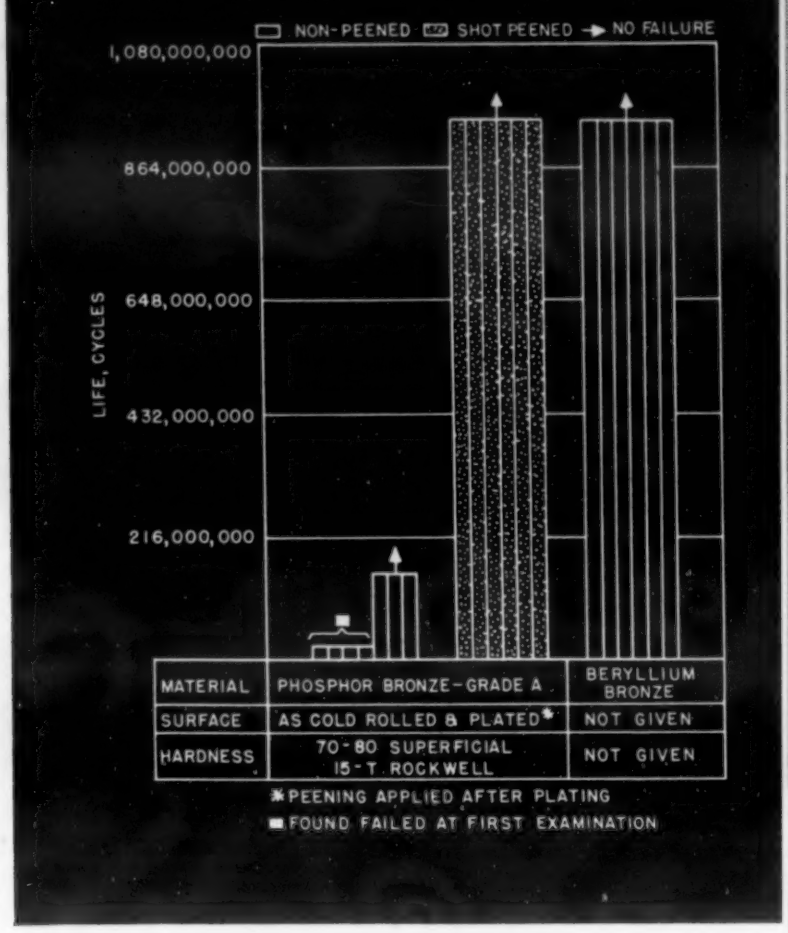
The original machine developed at the Philadelphia Works has been in operation for about one year, and is used to apply contact rings of silver which encircle the clamping bolt holes on copper bus bars. Previous methods called for the cementation of a silver ring, punched from sheet stock 0.003 in. thick, on the bus bar through heat and pressure using mercury as a bonding agent.

This method required considerable preparation and heavy, expensive equipment which is normally grouped to promote flexibility, thus involving transportation of the work from one department to another. Considerable saving in material is realized by use of the electro-plating method in that a coating of 0.0005 in. is satisfactory to produce the same net result.

Shotpeening experiments show that this treatment increases stress corrosion of some nonferrous metals such as brass, aluminum and magnesium, in some cases showing an increase in life up to 40 times.

Shotpeening of Nonferrous Metals

by **HAROLD A. KNIGHT,** *News Editor,* MATERIALS & METHODS



Here are graphic results of peened and non-peened brake armature support diaphragms, the test, for fatigue durability, consisting of laboratory bending fatigue. Current passing through a brake coil applied an oscillating load, 60 cycles per sec. Non-peened specimens are represented by open spaces; peened, by speckled surfaces. The peening was applied to phosphor bronze specimens. Beryllium bronze, not peened, was apparently the equal of the peened phosphor bronze.

MOST OF THE EXPERIMENTS and experience with shotpeening have involved ferrous metals, such peening proving effective where the part or component in service has to stand one or more of some half dozen kinds of stresses, such as fatigue. The effect of peening on nonferrous metals is perhaps less known and not so far advanced. In antiquity, however, the hand peening with a rounded hammer involved both types of metals—ferrous for making swords and hammered brass, and bronze for ornamental and utilitarian items.

During the war considerable experimental work with peening was organized by governmental technical services. Thus, in one cooperative project 135 separate industrial and research organizations worked. Probably about 10% of the materials experimented on were nonferrous metals.

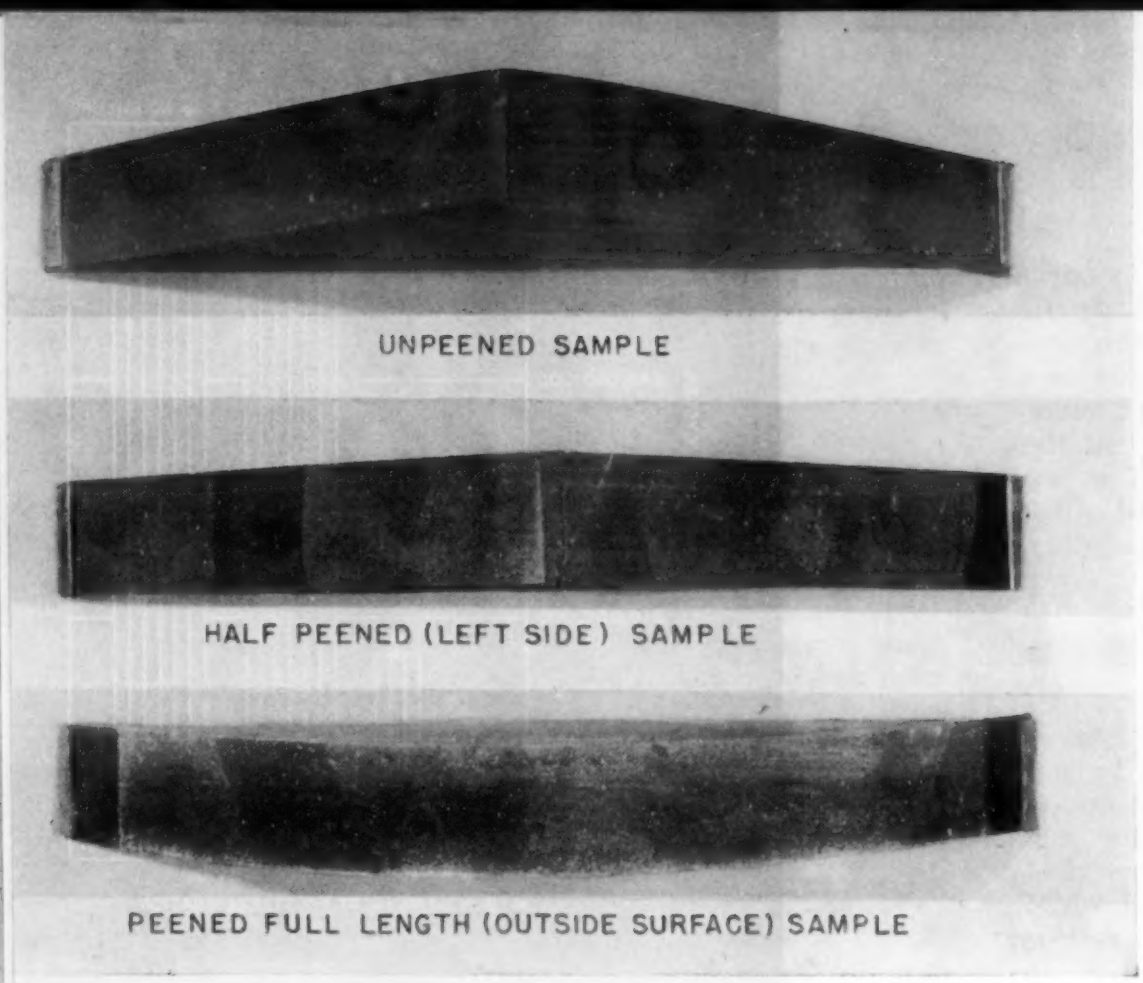
In these studies consideration was given to material, hardness, intensity of peening, shot size, shot type and nature of the surface before peening. Besides peening, other pre-stressing processes were used such as surface rolling, hammer peening and pre-setting. Studies were also made of high temperature effects on pre-stressed specimens of certain super alloys.

Among the nonferrous metals, studies were chiefly in two categories: (1) effect of shotpeening on fatigue strength, and (2) on stress corrosion cracking. Other tests dealt with peening's effect on season cracking, crushing strength and static strength. In the first category experiments were conducted on aluminum, magnesium, nickel and various nickel alloys and on bronze. The loads applied involved one of the following: reverse bending, bending, rotating beam and service. On stress corrosion cracking, materials studied were magnesium and brass.

It is interesting to note that the "father" of modern shotpeening, H. F. Moore, research professor of engineering materials, emeritus, University of Illinois, started off his experiments as a boy with nonferrous metals. During high school days he spent spare time in electrical experiments in his attic. He needed some "spring brass." His friend, the local telegraph operator, advised him: "Take the brass back from a discarded thermometer, hammer it all over with a round nose hammer and you will find that it becomes springy and holds its shape no matter how much it vibrates."

Fatigue Durability Tests

Some fatigue durability tests gave the following results: Peening improved duralumin by 16%; mag-



The photographs and typed-in captions are self-explanatory in showing the effect of peening on J-1H alloy in resisting stress corrosion.

nesium alloy, Elektron AZ 31, gained 26%, with Elektron casting, 24% better. Phosphor bronze wire improved 43% and sheet, 54%.

Certain aircraft domes of 14 ST aluminum alloy forgings were peened inside and outside except the tapped hole at the top and clamping surface of the flange. Threads were cold-rolled with a special tool. Two domes were bolted together to form an assembled accumulator. Then cyclic hydraulic pressure was applied, 90 cycles per min. A non-peened dome failed at 89,200 cycles; a peened, at 121,000. The experimenters were evidently conservative when they said: "The limited data indicate that the component *may* be improved by peening."

An experimenter with General Electric Co. reported that shotpeening was beneficially applied to a machine part (a phosphor bronze brake armature support diaphragm) as thin as 0.008 to 0.010 in. The shot used was commercial malleabilized iron, 0.016 to 0.019 in. dia. The shotpeening intensity was too low to measure with standard apparatus. Coverage was considered ample as judged by visual examination. The part, shaped somewhat like a quarter moon, but actually a strip ¼-in. wide, was peened all over. Under the blast it was manipulated by hand. A compressed air type of machine was used. The test or load consisted of laboratory bending fatigue. The part was assembled in its normal brake mechanism. A.c. current was passed through the brake coil giving a magnetically applied oscillating load at the rate of 60 cycles per sec.

These tests are particularly interesting because of the relatively large number of cycles to failure. Durability of the phosphor bronze diaphragms is increased by peening. Also, in the non-peened condition diaphragms of beryllium bronze are shown to be superior to those of phosphor bronze.

Actual results were expressed by the experimenter in graph form. Four specimens of phosphor bronze, non-peened, were found failed at the first examination. Three other non-peened samples had undergone around 150 million cycles before failure. However, six specimens of peened samples were still going strong at 900 million cycles. (Six non-peened beryllium bronze specimens did equally well.)

Another case history involves a nose wheel torque collar of aluminum alloy. Critical areas and fillets were peened (the internal bearing surfaces and tapped holes being masked). The test or load was a laboratory fatigue similar to that given in service, applied pneumatically. The average durability of two shotpeened collars was 130% greater than those not peened.

Stress Corrosion Resistance

An important purpose of shotpeening nonferrous metals is to extend stress corrosion resistance. Thus, in cold drawn brass (copper 68.6; zinc 31.3) cups, 1/32 in. thick, and exposed after peening to an ammonia atmosphere, the time before cracking was extended to 23 hr. from 2½ hr. for non-peened brass, for one specimen and to 100 hr. for another.

It might seem that in the case of a formed or semi-formed part it is best to shotpeen both inside and out. This observation was made with a 70-30 cartridge brass cup, 0.040-in. thick wall, 1⅞ in. dia. and 1⅜ in. high, tested for stress corrosion cracking. The test piece was a drawn, unannealed cup. It was treated for testing with a 1% mercurous nitrate solution containing 1% concentrated nitric acid.

The experimenters reported that cup life, when peened with shot or grit on both inside and outside, is "much greater" than for non-peened cups. Peening outside only or inside only usually made for some increased life. In such cases of outside-inside peening, the degree of peening is important. Thus, where too high intensity was given on outside-only peening, conditions made for early failure at an inner surface because of high residual tension stress in the inner sur-

face layers imparted by peening. Where lower intensity was observed in the peening there was a resulting gain in life because of more favorable distribution of internal stresses.

In another case where the brass cup was subjected to ammonia atmosphere, generated by 100 cc. of 75% ammonia hydroxide solution (by volume), the stress corrosion cracking life increased many times by peening both outside and inside surfaces.

In the case of a large brass cartridge case the experimenter observed that stress corrosion cracking was more effectively decreased by large shot at high intensity than by small shot at lower intensity.

As an antidote to stress corrosion cracking 52 SH magnesium alloy, peened with glass beads, showed no cracking at the end of 12 days, though unpeened it failed in 2½ min.

Magnesium alloy (AMC-57 SH) test strips, when stressed and exposed to potassium chromate and sodium chloride, failed in 120 sec.; when peened, they lasted 10 days with no cracking or corrosion. J-7H magnesium alloy sheet failed in 9¼ min.; when peened it lasted 430 hr.

Another interesting series of experiments was conducted on Dow J-1H magnesium alloy sheet since this material is highly susceptible to stress corrosion in the as-received condition. Specimens were prepared from sheet, 0.064 in. thick. Strips 1 by 10 in. and 1 by 9 in. were stressed by bending into arcs with 8½-in. chords and held in this position during testing. The different length of specimens provided 2 deg. of stress for observation of the effect produced by this variable.

Stress corrosion was applied in the following manner. An 8-hr. cycle was used in which samples were immersed for 4 hr. in tap water, then dried for 4 hr., the duration of the complete test being 30 days.

In Group A, six samples each of 10-in. strips and 9-in. strips were bent into arcs, then peened full length on the outside surface. After 30 days all samples were intact, with neither failures nor cracks.

In Group B three samples each of 10-in. strips and 9-in. strips were peened one-half their length on both surfaces, then bent into arcs. All failed in the unpeened portion after one day of the test.

In Group C three samples each of 10- and 9-in. strips were peened one-half their length on the outside surface only, then bent into arcs. The 10-in. strips failed after one day of test; the 9-in. strips failed after four days—all in the unpeened sections.

In Group D, six samples each of 10- and 9-in. strips were not peened and bent into arcs, forming 8½-in. chords. As to the 10-in. specimens, one failed after one day, the remaining, after four days. Of the 9-in. strips, one failed in 4 days, the rest failing at intervals, all being broken after 13 days.

The conclusion of the experimenters with this J-1H magnesium alloy sheet is that shotpeening, especially following forming, decreases to a marked degree the tendency of this alloy to corrode under stress.

Other experiments involved the influence of shotpeening on season cracking of brass. A non-peened brass cup failed in 2½ hr. in an ammonia atmosphere, whereas a lightly peened specimen was undamaged after 100 hr. exposure.

Other Applications for Peening

An interesting application has been to cure porosity in aluminum die castings subjected to pneumatic or hydraulic pressures. In the case of one part leakage was reduced from 50% of all parts made to 20%; in another case from 16% formerly to 4% after peening. One maker of such die castings shotpeened on both sides of the casting in a rotary-type, multi-table machine. As a result 90% of the castings had no leakage, while 10% had only slight seepage.

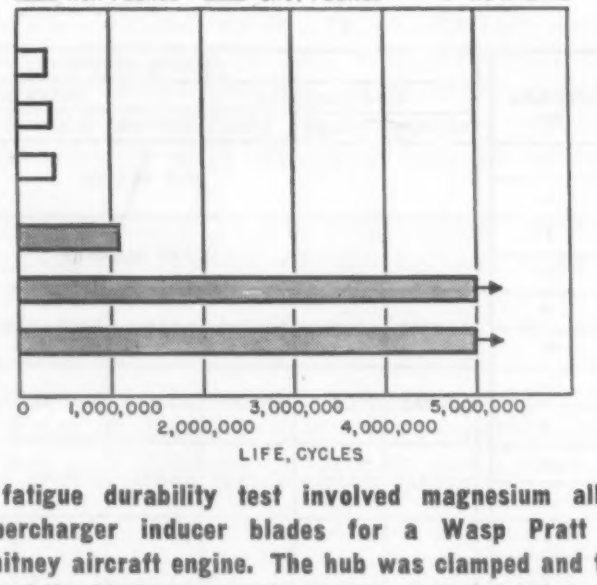
The International Nickel Co. is experimenting with shotpeening of various nickel alloys. A novel use of peening is testing the silver adhesion to silver plated steel bearings as practiced at Pratt & Whitney Aircraft. The hammering action of the shot produces deformation of the silver. If the silver is poorly bonded it will extend and flow and become blistered. Several makers of aluminum cooking utensils have shotpeened for decorative purposes and also to resist corrosion pitting.

Types of Shot Used

The most commonly used shot for peening is commercial chilled iron, with hardness of 800 to 900 Vickers, used chiefly on hardened work. A softer, but tougher, shot is heat-treated cast iron. Considerable progress has been made in developing steel shot, capable of withstanding the peening action more effectively than cast iron.

Pratt & Whitney Aircraft have found that the conventional chilled iron often becomes embedded in soft metals such as aluminum, hence choose a softer shot, "Mallabrasive." Others have found that when shot particles become embedded, one may immerse the peened metal in hydrofluoric acid—or chromic, then hydrofluoric—thus effectively removing the particles.

In fact, some go as far as to advise against ferrous



A fatigue durability test involved magnesium alloy supercharger inducer blades for a Wasp Pratt & Whitney aircraft engine. The hub was clamped and the tip of the blade was mechanically stroked 0.080 in. in both directions. The speckled spaces represent the peened specimens which proved longer-lived than the non-peened.

shot in any form for soft metals, using instead glass beads, walnut shells, apricot pits or plastic.

Those Who Did Research

Prominent among the 135 organizations cooperating in war research on nonferrous metals were the following: Battelle Memorial Institute, Lockheed Aircraft, International Nickel Co., Douglas Aircraft, Consolidated Vultee Aircraft, Dow Chemical Co., Pratt & Whitney Aircraft, General Electric Co., Aluminum Co. of America, General Motors Research, Rensselaer Polytechnic Institute, the Navy Dept., and the Springfield Armory.

Most of the case histories mentioned in this article are from war time researches under auspices of the Office of Scientific Research & Development (OSRD). Copies of these researches are now obtainable in form of photostats or microfilm from the Office of Technical Services, Department of Commerce, Washington 25. There are three reports, identified: (1) (19515) OSRD 3274; (23777) OSRD 6647, and (31211) OSRD 4825. These reports consist of text, photographs, tables and graphs.

Observations and Comments

J. O. Almen, head, mechanical engineering, Research Laboratories Div., General Motors Corp., told us recently that there are apparently no important additions to make to the data accumulated during the war on the gains in fatigue strength by prestressing insofar as nonferrous materials are concerned.

The theory of peening, of course, is that each shot acts as a tiny peen hammer, making a small dent in the surface of the metal and stretching the surface radially as it hits. There results a plastic flow of the surface fibers beyond their yield point in tension, in a layer that extends 0.005 to 0.010 in. below the surface. The fibers underneath are not stretched to their yield point and retain their elasticity. The two types of fibers are bonded to each other. The inner fibers force the outer ones to return to a shorter length than they would tend to remain. In the equilibrium which results, the surface fibers are in residual compression, while the inner ones are in tension.

Surface compression stress is several times greater than the tension stress in the interior so that when working stresses are applied tending to impose a tension stress, that tension is offset by the residual stress in the surface layer. Fatigue failures generally result from tension stresses.

In applying this theory to certain nonferrous metals, Mr. Almen and his co-experimenters find that the gain in fatigue strength from peening is dependent on the ability of the specimens to retain the residual stresses that have been induced. When these prestresses are lost, shotpeening is usually harmful because all that remains is the roughened and fractured surface produced by peening.

It is for this reason that the rotating beam and similar reversed stress fatigue tests are not capable of indicating the gains that may be expected in machine elements that are to be loaded in one direction only, whether in bending or in torsion. Under reversed loading the residual compressive stresses are readily lost by creep, whereas in one-direction loading this loss is not serious.

Mr. Almen states further that magnesium does not readily support a continuous load and tends to relax or creep with time. We would, therefore, not expect magnesium to be greatly influenced by residual stresses, since such stresses would be lost by creep.

An experimenter at Massachusetts Institute of Technology, in explaining failure of peening to improve fatigue durability, suggested that perhaps the specimens were already compressively stressed near the surface due to heat treatment, hence peening could not add additional compressive stress.

SPECIMEN NO.	PEENING INTENSITY							EXPOSURE TIME BEFORE CRACKING, HOURS	LOCATION OF CRACK
	INNER SURFACES			OUTER SURFACES					
	BOTTOM	SLANT	SIDES	BOTTOM	SLANT	SIDES	RIM EDGE		
5	NOT PEENED							2-1/2	SIDE
6								2-1/2	SIDE
7	.003A2 ALL OVER							8-1/4	SIDE
8								13	SIDE
9	0.003A2	0.003A2	0.007A2	0.003A2	0.003A2	0.007A2	0.007A2	22-1/4	SIDE
10								50	SIDE
11	0.003A2	0.007A2	0.007A2	0.003A2	0.007A2	0.007A2	0.003A2	7-3/4	BOTTOM
12								7-3/4	BOTTOM, SIDE
13	0.003A2	0.003A2	0.003A2	0.003A2	0.007A2	0.007A2	0.003A2	11	SIDE
14								50, NO CRACK	NONE
15	0.004A2	0.004A2	0.004A2	0.004A2	0.008A2	0.008A2	0.008A2	25	SIDE
16								100, NO CRACK	NONE
17								23	SIDE
18								48	SIDE

NOTE: COMMERCIAL MALLEABLIZED IRON SHOT USED ON SPECIMENS NO. 7 THROUGH 14.
COMMERCIAL CHILLED IRON SHOT USED ON SPECIMENS NO 15 THROUGH 18.

Here are more cold-drawn brass (68.6-31.3) cups exposed to stress corrosion influences, revealing details on peening intensity. Among details are inner and outer surfaces, at what part of the cup the peening was directed, exposure period before cracking, and location of the crack, if any. (As to intensity, 0.003 A2 means: Height of arc, resulting on test strip from peening one side, is 0.003 in. The "A2" specifies type of Almen test strip used, the alternate type being "C2").

Salvage of Cast Iron Through Heat Treatment

by **DAVIDLEE V. LUDWIG,** *Consulting Materials Engineer*

FOR MANY YEARS conventionally educated engineers tended to frown upon cast iron as a material for other than the least exacting applications. To a large extent they were right, in so far as the type of irons being produced, until recently, were concerned. There were many places where large volumes of cheap metal were required wherein service conditions were such as not to require a consistent grade of material, and price alone was the initial reason of choice of metal for the part. In the days when commercial cast iron was going for as little as 2¢ a lb. there was, in fact, no metal which could approach it from the standpoint of initial cost.

However, intensive study on the part of many forward thinking metallurgists, financed by numerous large, interested management groups, has increasingly removed cast iron from the cat and dog category and is moving it over into its rightful field, where it promises to become one of the most economically important raw materials for many engineering jobs formerly denied to it, yet somewhat less effectively done by other conventionally desired materials.

The recent war, partly through a process of attrition of supply of the more recognized raw materials, but largely through a process of accentuation of the importance of new information in the long neglected fields of materials design engineering and materials conservation, accelerated the trend towards application of controlled grades of alloyed irons in applications formerly considered strictly reserved for steel, either cast or forged.

Some of the most successful applications have been in internal combustion engine parts, other than cylinder blocks and heads. Camshafts, crankshafts, and in some instances, even connecting rods have been cast from various alloyed cast irons with not only the expected gains in regards to machining time, but with sometimes quite unexpected improvements in engine performance with respect to increased bearing life. Other improvements include increased freedom from vibration, greater freedom from crankshaft failure through torsional stresses and, in the instance of camshafts, marked improvement in retention of cam contour accuracy over prolonged periods of operation even under conditions of irregular lubrication.

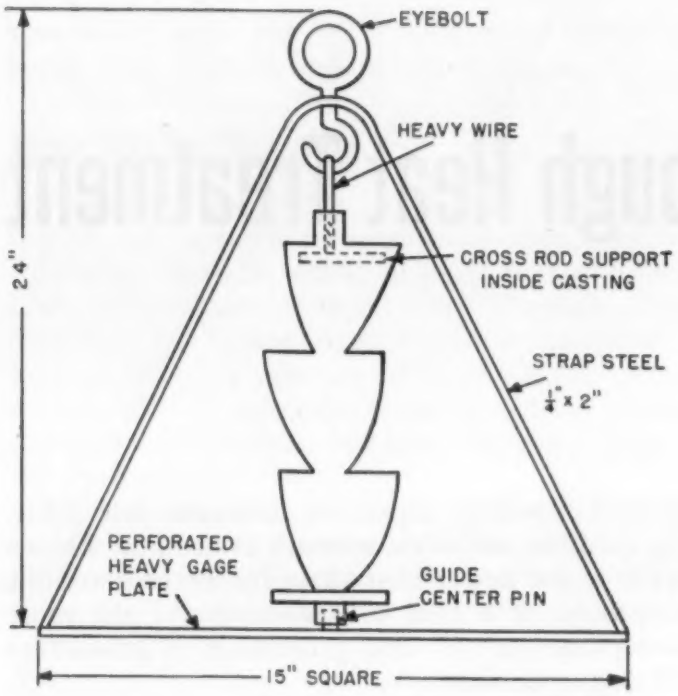
The success which is being encountered in many branches of production by utilization of the manifold advantages offered by a material with such superior machining characteristics, relative low initial cost, unusual dampening capacities, inherent self lubricating qualities and high strength as are now known to apply to the newer iron alloys has necessitated the development of a field of knowledge of the more erudite phases of cast iron processing in production machining operations.

One of the defects most frowned upon in cast iron application in the past has been its tendency to grow when subjected to wide changes in temperature. This lack of dimensional stability has earned for it a bad name, but in point of fact, the error has lain in the judgment of those who chose it for applications wherein it would be subjected to temperatures at or near its range of critical transformation, such as exist in furnace grates, heat treating conveyor parts and the like. The selection of cast iron for such applications has generally been guided by the erroneous concept of initial low cost, rather than inherent ability of the material to perform satisfactorily.

Within temperature ranges of conditions normal outside of melting and processing furnaces and other high heat units, cast iron alloys have exceptionally stable dimensional characteristics when properly prepared and machined. However, the very defect which has militated against its misuse may be converted into a most effective ally in the control of production losses through machining practices. In the fabrication of parts such as crank or camshafts, it is inevitable that precision dimensions will be lost through undermachining of a given section, with the result that an otherwise useful part, in which much time is invested, will be scrapped. The ability of cast iron to grow offers a ready means of control of such losses.

Sperry Gyroscope Co. was using a high grade of cast iron as the material in the ballistic cams of detector mechanisms. There were three types of cam units involved, weighing from 15 to 55 lb. each, as cast. The most complex unit consisted of three three-dimensional unit cams cast on a single axis. The function of the triple cam was to cross-cordinate three data computations relating to position of an aircraft in flight, converting the mechanically deduced positioning data into electrical impulses needed to guide searchlight and gun battery equipment.

The defective nature of the iron being used was brought to the management's attention with the unexpected rejection of six completed triple ballistic cams by the government inspectors. The loss of



The cam castings were about 18 in. long. During heat treatment they were suspended in a jig of the type shown here to prevent distortion.

$4200 represented by the six units was nothing to the implied loss which was obvious, if an appreciable percentage of the castings on hand, in stock and process, were of comparable structure.

The nominal composition of the cast iron had not been too closely guarded up to that date. The final modified specification that was evolved by the Materials Engineering staff, following discovery of the defective material, was as follows:

Desired Chemical Composition, Per Cent

Total carbon	3.05 to 3.30
Combined carbon	0.60 to 0.75
Graphitic carbon	2.45 to 2.65
Silicon	1.80 to 2.10
Manganese	0.60 to 0.80
Nickel	0.50 min.
Phosphorous	0.20 max.
Sulfur	0.01 max.

Required Physical Properties

Ultimate tensile strength	52,000 psi. min.
Transverse fracture	3,000 actual min.
Deflection	0.30 in. min.
Brinell hardness number	196 to 220

The above specification details were evolved in an effort to secure a grade of controlled iron from the source which would insure the characteristics essential to the performance of the cams. The only points of true significance to the functional purpose were the hardness, which governed both the ease with which the precise dimensions could be attained as well as the ability of the material to stand up under load, and the size and distribution of the graphitic particles, which determined how true to the normal contour the work surface would be.

The actual physical properties listed above, in conjunction with the high carbon iron specified, probably cannot be insured, in the range of Brinell hardness desired. In practice, these combined properties were not obtained, nor were rejections based on failure to conform to all limits, but rather on actual structural details affecting the machinability, wear resistance and freedom from gross pitting. If this sounds contradictory to the essential sense of this report, it is, but circumstances with regards to supply and particular with respect to production consignment requirements prohibited any other policy at the time, though ultimately, due to the lack of sources of supply of sufficiently high quality iron (another contradictory statement in so far as the nominal purport of this story is concerned), a substitute material was developed to replace the iron.

The actual range of quality of the material received up till the time of the rejection of finished parts was as follows (based on rapid checking of previously received samples);

Actual Chemical Composition Range, Per Cent

Total carbon	2.20 to 3.50
Combined carbon	0.40 to 0.85
Graphitic carbon	1.80 to 2.75
Silicon	1.50 to 3.20
Manganese	0.40 to 1.00
Nickel	0.25 to 1.30
Phosphorous	0.15 to 0.40
Sulfur	0.005 to 0.15

Actual Physical Properties

Ultimate tensile strength	28,000 to 45,000 psi.
Transverse	1800 to 3800 lb. actual
Deflection	0.14 to 0.38 in.
Brinell hardness number	140 to 240

The test specimens supplied had been duplicate transverse bars of the standard type, 18 by 1⅛ in. Tests were made with standard compression equipment on a Baldwin Southwark machine. Brinell hardness numbers were determined both by means of 3000 kg. Olsen Brinell impressions and by means of Rockwell B hardness tests.

Following rejection of the six completed cams, a complete survey of the condition of every cam in stock and production was made. The project disclosed the presence of over 700 units, in various stages of production, which were too soft to be usable. Hardness was used as the determining test, for it was most representative of the performance defect, which was the basis of the initial rejection.

Loss of the 700 units meant loss of approximately six months of cam production time, a cash loss of perhaps $500,000, and a consignment loss of hundreds of completed units. Therefore, management wished to ascertain what, if anything, could be done to save the group. Permission was granted to experiment with 24 of the otherwise scrapped cams. Knowing that the material would grow when heated and quenched, the only questions to be answered were (1) the correct heat treatment for processing the lots, (2) the type of fixtures necessary to prevent distortion of the triple cams, and (3) whether or not heat treatment would result in a redistribution of the graphite with an increase in the combined carbon content and a reduction in size of the free graphite.

After experimentation with 1-in. thick round specimens cut from five representative arbitration

bars, 15 pieces from each bar, it was determined that a heat treatment procedure could handle all of the various compositions represented by the wide range of different heats, in the following manner:-

Five sample heat treatments were performed, each heat containing three samples from each of the five bars. The purpose of the treatments was to determine which combination of transformation temperature, quench means and drawing methods would result in the desired hardness, optimum growth and best redistribution of graphite. It was discovered that all compositions responded suitably to oil quenching from 1650 to 1700 F, in so far as growth and initial hardening were concerned. However, due to the fact that the varying compositions produced hardness variations from 350 to 550 BHN. in the as-quenched specimens, which precluded a single drawing time and temperature, the most difficult phase of the experiments was the determination of proper drawing procedures for tempering the irons back to the range of 196 to 220 BHN.

The final production procedure involved heat treatment of all defective cams for 1 hr. at temperature in a controlled atmosphere furnace at 1650 to 1700 F, quenching in hot oil, then cooling slowly to room temperature. When cool enough to handle, Brinell hardness numbers were determined, by means of portable impact hardness testers, the quenched cams were divided into groups, according to their quenched hardness, from 350 to 550 in steps of 50 BHN. and were then tempered or drawn by holding them for 30 min. at temperature ranging from 1100 to 1300 F. The hardest as-quenched castings were drawn for 30 min. at 1300 F, and each successively softer group drawn at successively lower temperatures in steps of 50 F. By this means, all 700 units were brought into the desired range of hardness, without exception.

To prevent distortion of the triple cams, which were 18 in. long and varied from a cored journal diameter of 1½ in. to a maximum cam divergence from center line of approximately 3 in., jigs were built to suspend the cams from one journal in a verticle position. The lower journal end bearing barely touched the bed plate when the cam was placed in the furnace. This suspension tended to intensify the tendency for lateral growth, and actual growth in excess of 0.01 in. was frequently met, but in view of the fact that the overall length of the partially finished cam was not important, and the fact that the journals were removed in the final production stages, this increase in length was unimportant. The triple cams were removed from the furnaces with special hook cranes which lifted through a large ring welded to the top of the jig; jig and casting were quenched together. In spite of the fact that many journals had been ground to parallelism and concentricity to dimensions of 0.0001 in., no cam was lost through distortion.

The atmosphere in the furnace originally was produced merely by setting the burners for reducing flames on a direct oil-fired furnace. This method was partially satisfactory, the reducing flames preventing pitting beyond a measured 0.003 in. However, the extent of the pitting of the finished journals endangered some of them which attained a growth of only 0.005 in. on the 1½-in journals. Therefore, fully controlled furnace atmosphere treatments were used for all but the first few castings, the parts being processed in electrically heated pit furnaces supplied with generated controlled atmospheres.

In spite of the close finish required on the locating journals, the growth of material, which varied from 0.005 to 0.015 in., was adequate to permit regrinding of all controlled dimensions on the salvaged cams. Furthermore, production reports showed a marked improvement in machinability of the castings, even over those which were initially satisfactory, and final polishing reports showed that the graphite size was reduced to an entirely satisfactory range. The men who polished the final data surfaces reported a greater freedom from grittiness, or tendency to develop scratches in final polishing. This probably was due to the reduction in graphitic pit size, which prevented tearing of polishing grit particles from papers of rougher surface and releasing them to spoil surfaces being generated by papers of finer finish.

The method of producing these ballistic cams, the methods of heat treating them for salvage, is directly applicable to cast iron engine cam and crank shafts. Verticle suspension of such parts is necessary to avoid sagging during processing, but aside from the necessity for having jigs and fixtures for the suspension of the various types of cams and shafts in production, no special equipment is required. Each alloy composition will have a different response to heat treatment, with respect to total growth, change in graphitic structure, quenched hardness and tempering treatments, but the particular method of handling required may readily be determined and standards established for the salvaging of production scrap.

Following the successful recovery of the 700 units, Sperry wrote standards covering the method, which were used for the same purposes by various other manufacturers licensed by Sperry in this country and in England, so that it was not necessary to lose any cams by reason of improper hardness or graphite distribution. Furthermore, once the growth characteristics were known, the cam department used it as a means of recovering stock on cams where surfaces had been ground under tolerances. This was a most important salvage tool, due to the extremely close tolerances which were held on the final data surfaces of the complex cams.

Therefore, it was developed that the most outstanding deficiency of cast iron for engineered applications, or unengineered use, its tendency to permanently increase in volume when heated above its critical transformation range, becomes an unusual ally in production of precision parts from alloy iron. This deficiency becomes an asset not to be found in like manner in any other high strength, low cost metal. Full use of the salvage potential of cast iron, through proper heat treatment, should enhance its value as a production metal through the overall reduction of the unit cost of finished items, through the ability to control the inevitable machine shop losses. The economic significance becomes increasingly important as the complexity of the part increases and the total time spent in attaining finish dimensions grows.

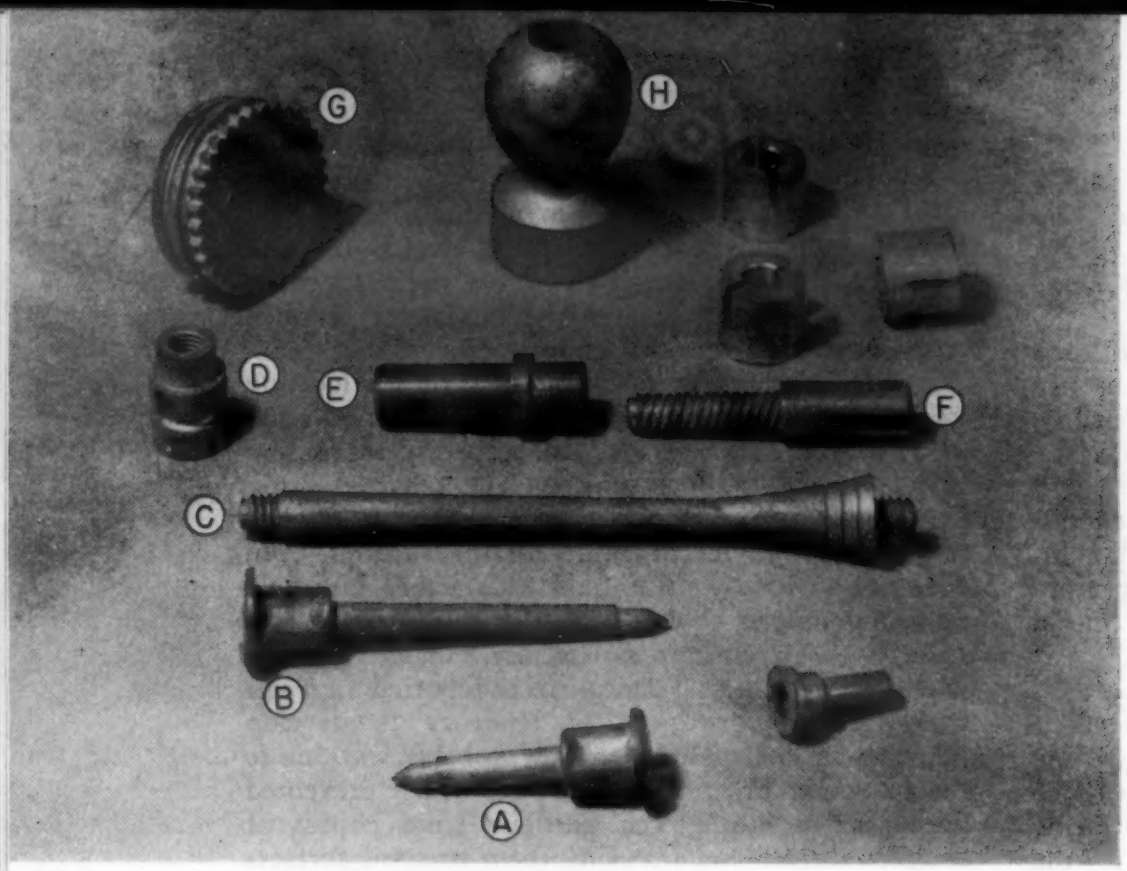


Fig. 1—Most of these parts, if made on the screw machine, would require primarily forming, turning and cutoff operations. Except for parts having axial holes and long slender pieces, chip loss would be moderate, if the parts were made by screw machines. In die casting, however, all axial holes and slots are cored. These would mean extra operations on the screw machines. Side recesses on parts A and B would be expensive if they had to be milled. Male threads on C are cast and go clear to shoulders as they could not do if cut. Parts D and H are tapped but the internal thread in E (mating with threaded shank of F) has a four-start left-hand thread of four-pitch presumably made by unscrewing a threaded core. Teeth cast on G would be coarse to knurl in a screw machine but no flash lines or ejector pin marks would appear on screw machine products.

Die Castings That Cost Less Than Screw Machine Products

by HERBERT CHASE

WAR EXPERIENCE, ESPECIALLY IN THE manufacture of fuse and similar parts, taught many manufacturers that die castings often yield a product costing less than can be turned out by the automatic screw machine. Actually, the basic facts were well established long before the war and they apply, of course, to a far greater number and variety of parts than were required for war-time products.

Tooling costs for die casting often runs higher than for screw machines, but frequently are offset by large savings in scrap and by decreased costs of secondary operations.

This is not stated to disparage the automatic screw machine. Its extraordinary utility is too widely known and too firmly established to be open to question. The screw machine, in fact, turns out thousands of products that the die casting machine cannot duplicate, especially in the most important ferrous metals.

In common with all machines, however, the screw machine has its limitations. Where these are controlling or where the die casting machine or some other machine offers a better balance of advantages over limitations, they are the logical ones to employ.

Nearly all examples of products here illustrated can be substantially duplicated on the automatic screw machine except for such secondary operations as are

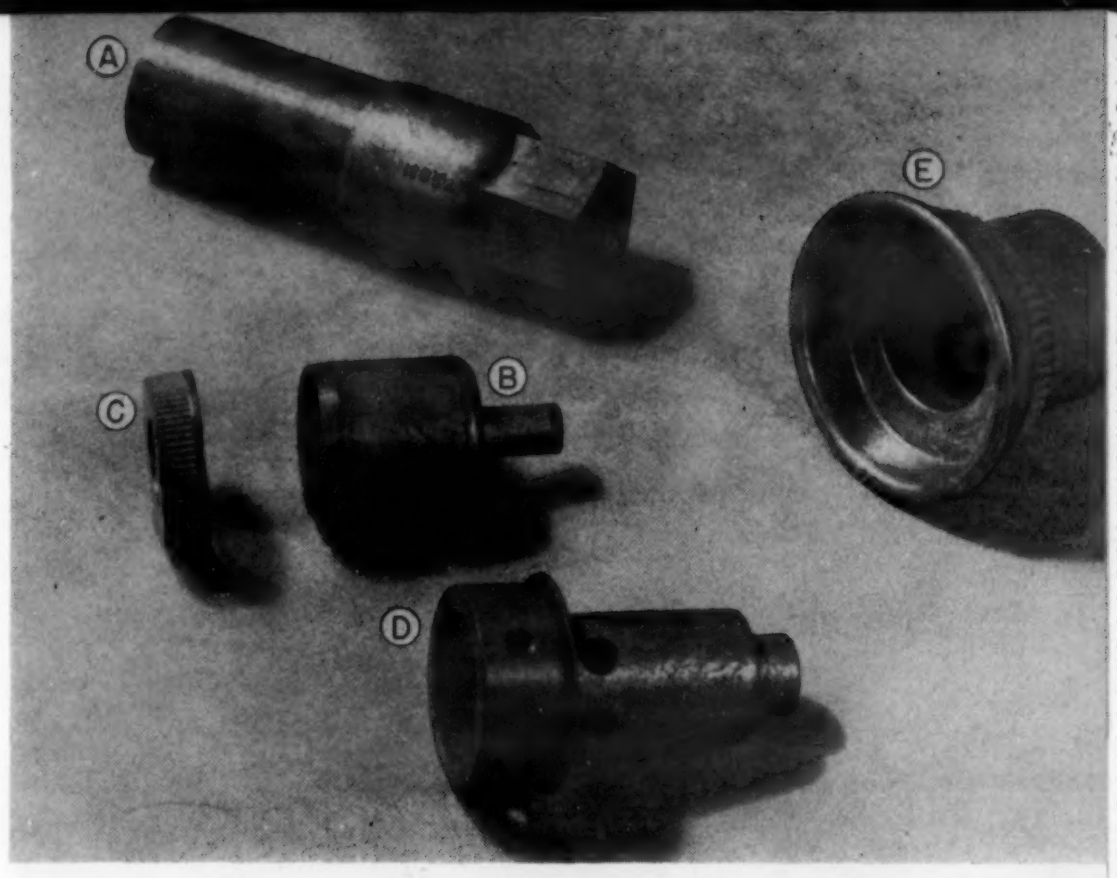


Fig. 2—Hollow parts, such as these, are expensive to make in the screw machine, especially when, as in A, B and C, the axial hole is small so that bar stock must be chosen and scrap in chips is high. All axial holes are cored. Part B is hollow nearly to the hex, the flats of which would have to be milled on a screw machine product. Part A has a ½-in. tapped hole on the hex end and would require operations after cut off on the screw machine. Part B is a cup with a machined exterior taper to fit cap C which has knurling formed by the casting die. Cross holes on D are drilled and three are tapped. Part E requires no machining save flash removal on flange bead, although the small end is rounded inside and outside, necessitating extra operations after cutoff if produced by screw machine.

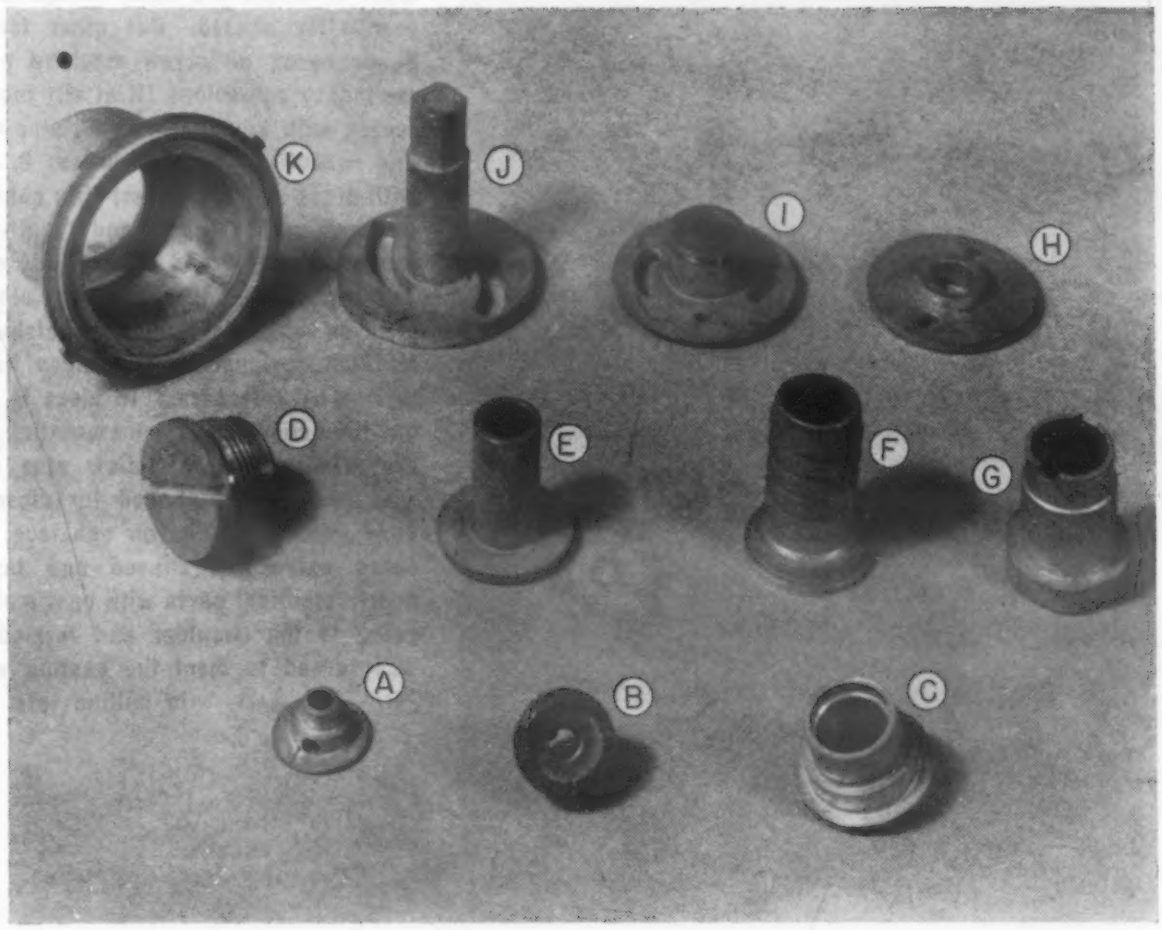


Fig. 3—Parts of this type, with flanges larger than barrels, are highly economical as die castings but wasteful in chip when turned from bar stock. Axial holes are cored, usually to finished size, adding further to economy in the die casting. Flange holes also can be cored, regardless of shape and size, and can be through or blind, straight, tapered or countersunk. Such holes, if of irregular shape, are expensive to machine on screw machine products. Part A has two shallow radial slots, B internal serrations and a semi-circular key, E a slot across its outer diameter, G slots with fastening ears on the end of the barrel. All these are formed by cores or male parts of the die at only slight extra cost for the die. Machining would cost much more. E has a flange with a radius, G a hex flange with its corners rounded and K a flange with ears and a circumferential bead of square section. J has a square on its shaft and F has grooves (that make necessary parting in an axial plane) but none of these features add extra operations. Part I requires a turned groove on the outside of the hub but the annulus in the hub is cored. Cup K would involve about 90% waste if cut from bar and then would lack features provided on the die casting.

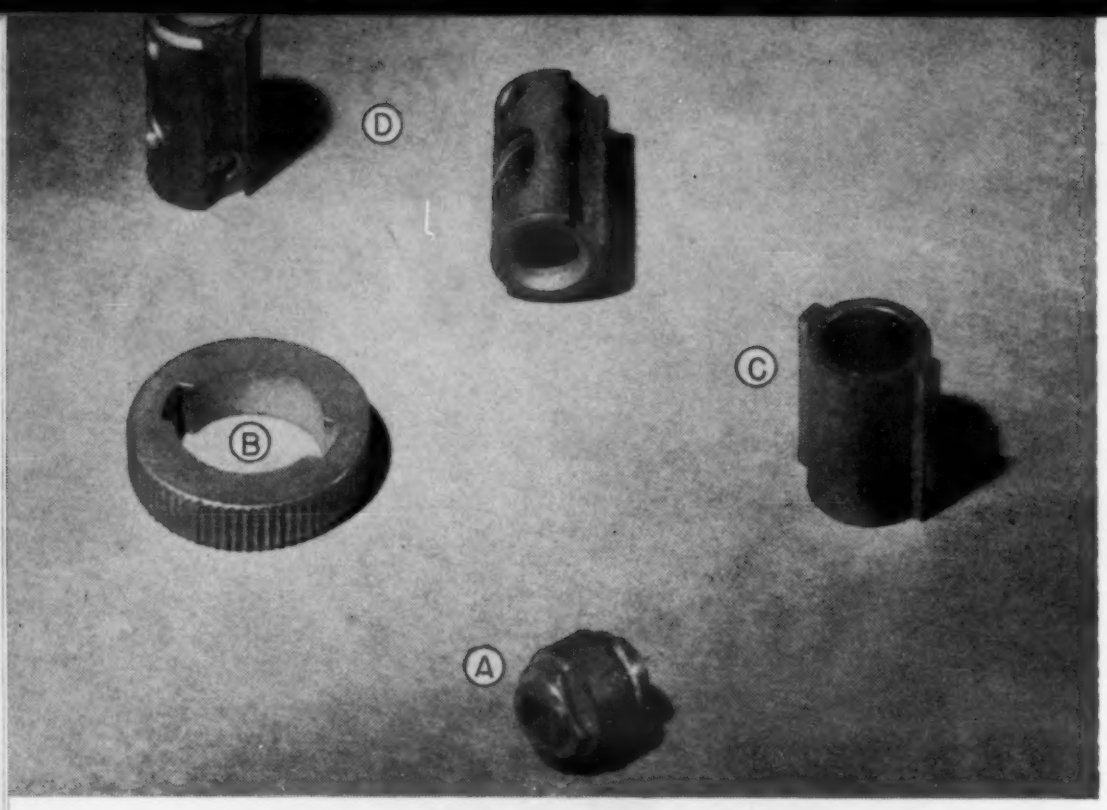


Fig. 4—To fabricate parts such as these on the screw machine would either require special extrusions or necessitate broaching, or its equivalent, to provide the square or keyed hole, the external keys or the keyway. But these parts are simple die castings, A having four flats formed by the die, besides the square cored hole; B having its hole with slots cored; C includes integral keys and D a cored keyway, end hole and two stepped cross holes. The only machining needed on these parts is that for flash removal.

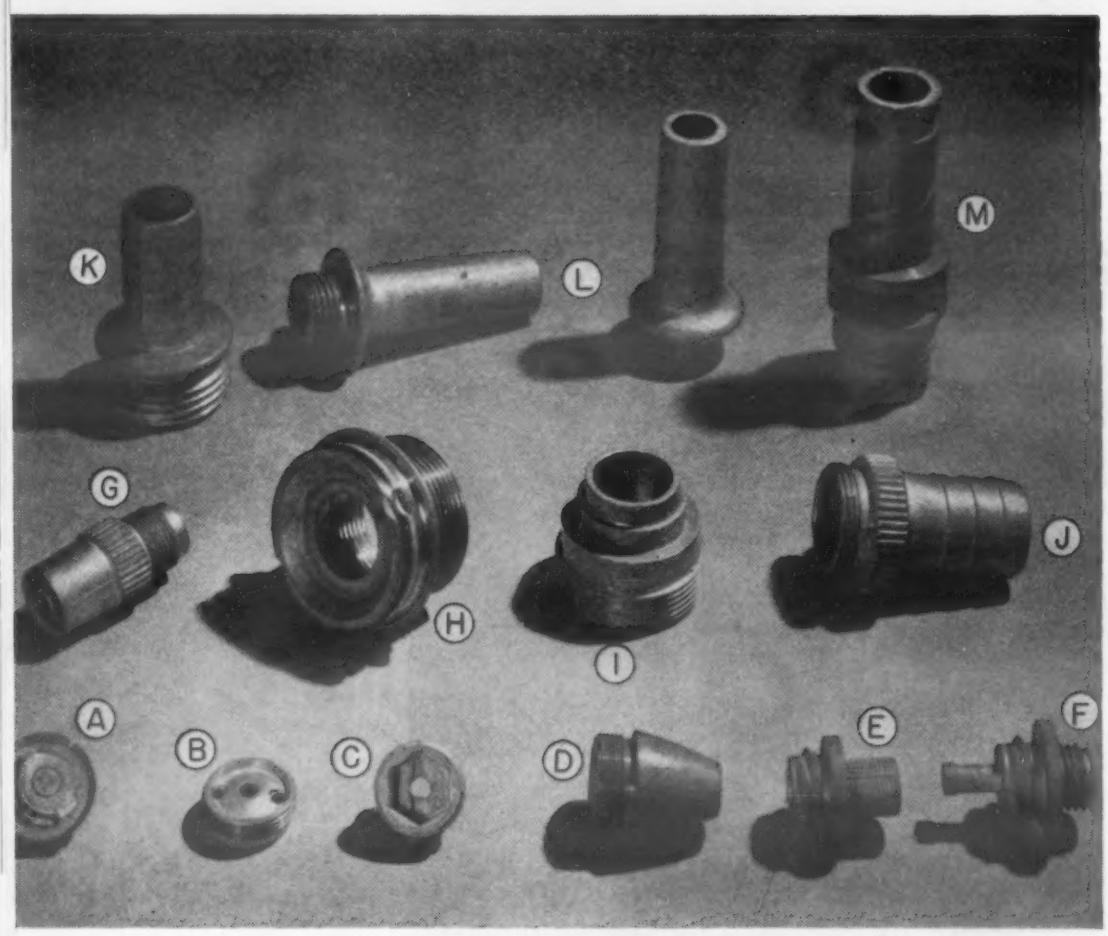


Fig. 5—All these die castings have male threads, most of which are cast, though some are partly or completely chased. But other features that cannot be produced on screw machine products except by secondary operations (if at all) include: A, step-cored recess with keying slots; B, step-cored through hole and two off-center blind holes; C, a cored hex recess with cross slot at bottom; E, a coarse cast thread and a shank with straight and longitudinal knurling; F, a coarse cast thread on one side of a knurled flange and a finer cast thread on the other side; H, turned grooves with longitudinally notched ridges between; M, double flange with bridges having radial faces formed by side cores. In piece M, the thread is cast but the helical and circumferential grooves and barrel are machined. I is hollow plug of aluminum alloy with cast thread chased for close fit and has two blind eccentric holes on one face. Fuse part D with cored ogive has chased and tapped threads, but nearly identical parts with cast male class—2 threads going to the shoulder and formed by a sleeve that was turned to eject the casting were also die cast in million lots.

often required on screw machine products, but it is often these secondary operations that give the die casting its chance to compete.

Basically, the automatic screw machine is limited to the use of bar or tubular stock, although it can be operated as a chucking machine if loaded by hand or by a magazine loading device. This chucking possibility is recognized but not often used. For simplicity in this discussion, chucking possibilities are omitted, but it is worth remembering that the automatic screw machine can be converted to a chucker and then even can be used effectively to machine die castings.

Because the automatic screw machine must use bar or tubular stock, it often creates a vast waste in chips. Virtually all its operations involve cutting and what is cut away is largely wasted although often having scrap value. This gives the die casting machine an important advantage because, although its product, as cast, involves considerable scrap, this scrap is immediately remelted and reused with only very minor loss.

Another disadvantage of the automatic screw machine is that it produces only surfaces of rotation, generally about one axis. Moreover, the time required for many cuts is quite long. In consequence, the shape of parts is limited and production is not always rapid. The die casting machine is not confined to

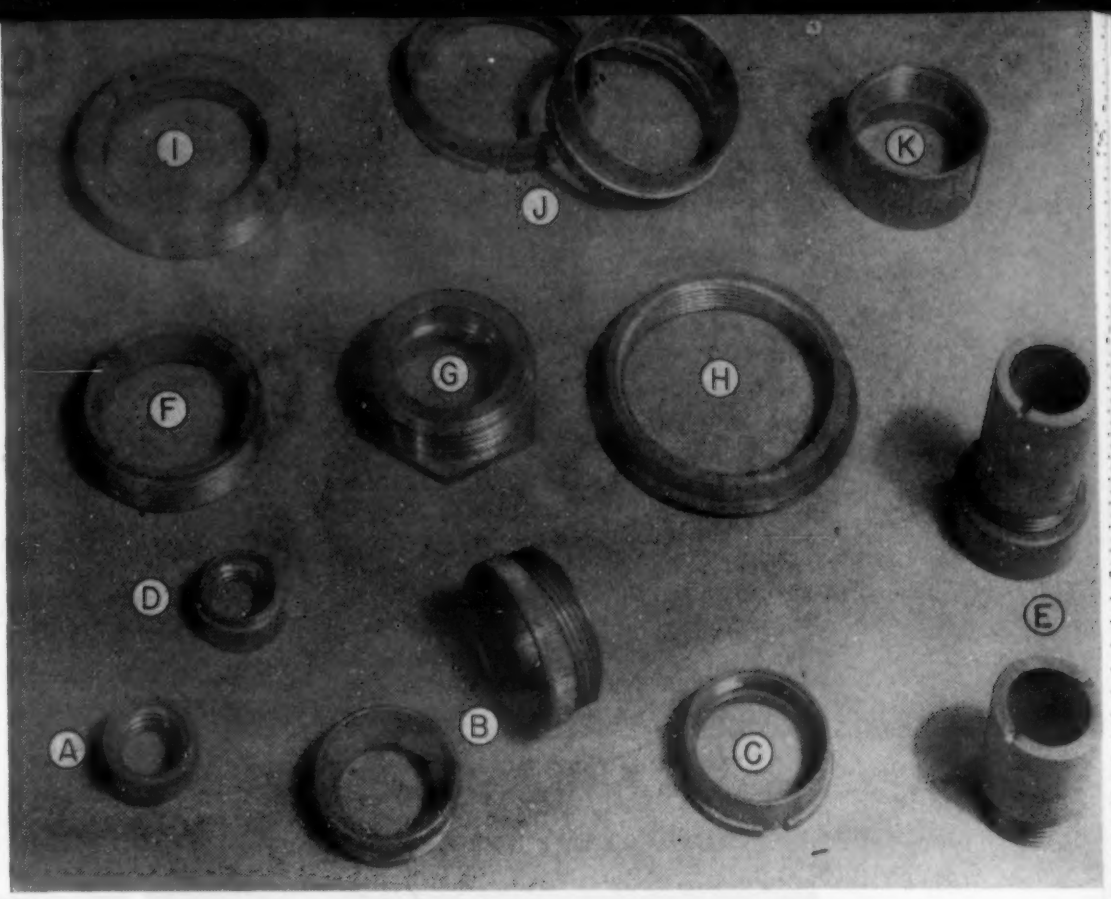


Fig. 6—Bushings and sleeves threaded internally or externally are readily die cast. They can be cut from tube on the screw machine, though seldom so economically as when die cast. Following parts have features that require secondary operations, if available at all, when part is made on the screw machine; B, six-start four-pitch male threads that go clear to shoulder and permit tightening the bushing in less than one turn; C, notched flange and internal thread clear to shoulder; E, nipple with internal flange slotted at opposite diameters; F, externally threaded bushing with four notches in one end; G, hex-flange bushing with beveled hole; H, flanged bushing with four-start internal thread clear through; I, externally threaded ring with blind holes cored for spanner; J, mating sleeves with notches, prongs and keyway under longitudinal rib.

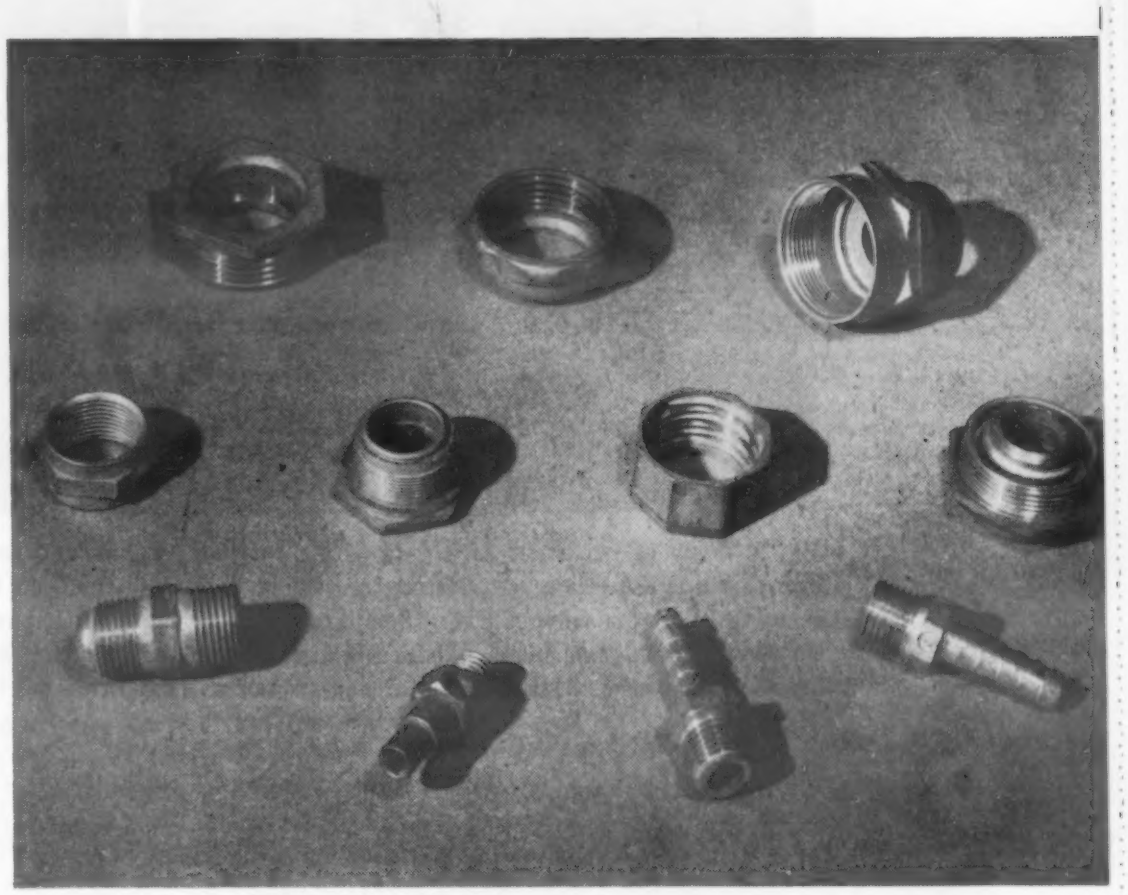


Fig. 7—Parts with hexes or octagons at largest diameter can be made on the screw machine from bar or tube similarly shaped or from round bar or tube if flats are cut in secondary operations. Often considerable stock is wasted in chips. Similar parts are die cast with less waste and have flats formed by the die. They can have cast threads running clear to shoulders. The smallest part has a cored axial hole of nearly triangular section and two cored blind cross holes in hex faces.

making surfaces of rotation. In general, it can perform the equivalent of the secondary operations; such as forming flats, slots or cross holes, or shaping both ends of the part. These operations, when done by the screw machine, necessitate transfer devices and attachments but often make necessary the use of a secondary machine if the basic part is made on the screw machine.

It is of even greater importance that the die casting machine shapes its product almost instantaneously. Some dwell follows the filling of the die to permit the casting to freeze and harden enough for ejection, but the cycle is a fast one. Often several parts, either duplicates or different, are made in each cycle. These are exceedingly important advantages and often are the controlling ones in giving the die casting preference.

But the die casting machine also has its limitations. It uses only nonferrous alloys and not a very wide range of these. About 75% of die casting tonnage is in one of two zinc alloys. Around 20% is in three or four aluminum alloys. Most of the remainder is in copper alloys, chiefly brasses, although some castings are based respectively on magnesium, lead or tin. No ferrous alloys are used in die casting.

Tooling for the die casting machine generally costs much more than for the screw machine, but when secondary operations are needed on screw machine

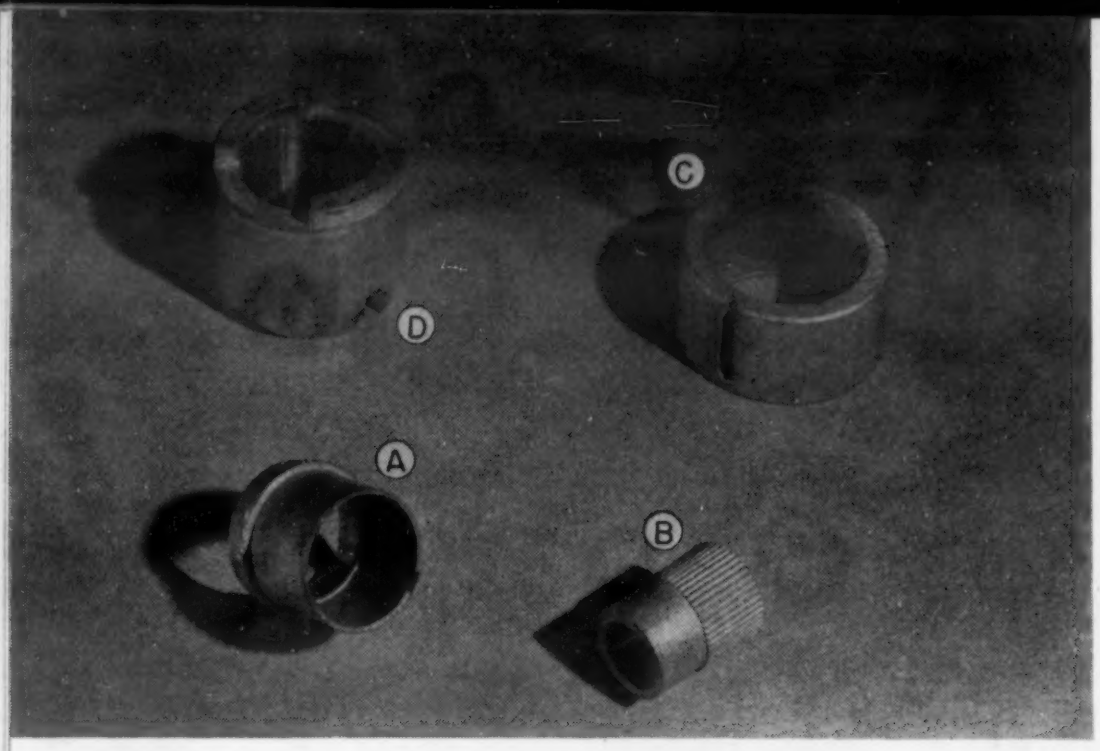


Fig. 8—Sleeves without threads often are cut in the screw machine but if, as in part A, a keyway under a longitudinal rib is provided, only a die casting is feasible. In die casting, an external keyway, part C, is readily formed, as are notched ends, as in part D. Part B, with stepped internal and knurled external dia., can be die cast or turned out on the screw machine but, in either case, the internal undercut recess has to be machined.

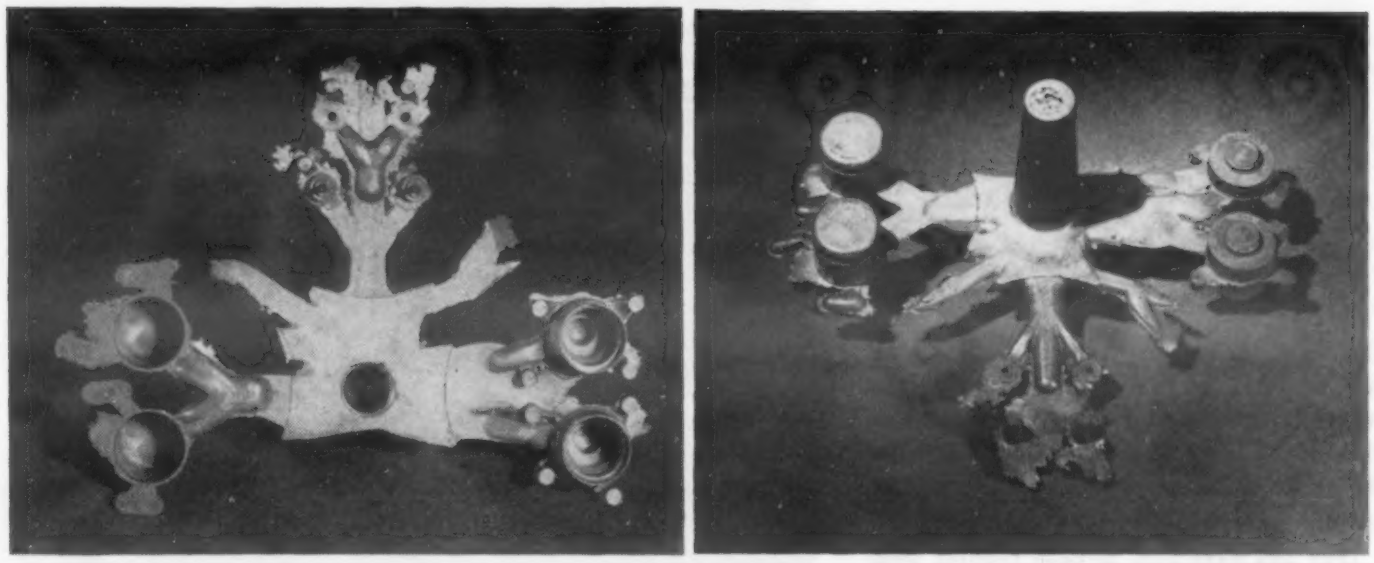


Fig. 9—View of two sides of a gate of die castings that include two sets of four parts each. These parts could have been substantially duplicated by cutting from bar stock on the screw machine, but only with large waste in scrap and at a much slower rate. Some 300 or more such gates are produced per hr. by one man on a single die casting machine. Cutting from gate and flash removal are rapidly done, using trim dies, substantially finishing the parts. Each of the four cup-shaped parts have raised lettering formed by the die on the closed end, a feature not provided on screw machine products.

products, the difference is decreased and may even favor the die casting. Lower tooling costs often favor the screw machine product but, as quantities increase the allowances for regrinding and resetting screw machine tools are made, the die casting generally gains in relative advantages.

In respect to dimensional accuracy and finish, the factors are numerous and generalizations can be misleading. Each of the processes has both limitations and advantages on these scores. Each also can produce detail advantages on other scores that the other cannot match.

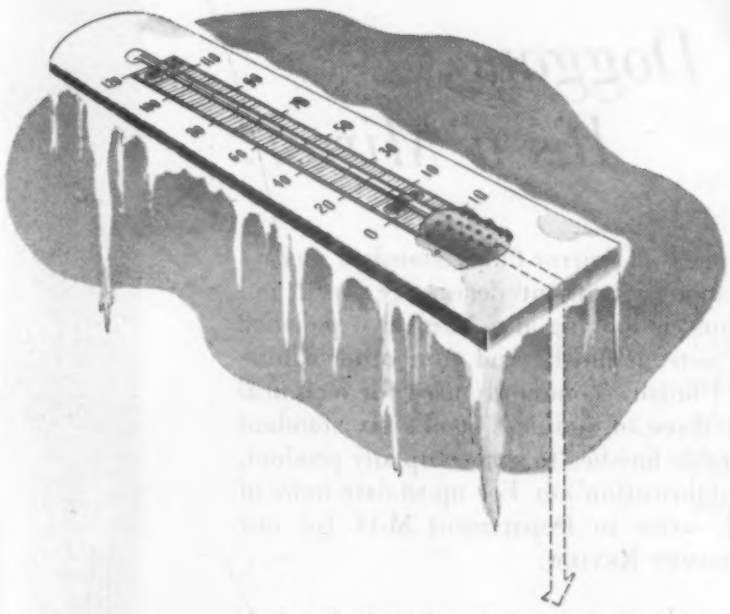
Examples here cited are all of parts die cast and virtually all in zinc alloy. Most of the parts could be die cast in the other nonferrous alloys if they were preferred, but female threads and fine male threads are rarely cast in alloys of high melting point than zinc. In general, cast threads, though adequate for many purposes, are inferior in fit and smoothness to cut threads. Many chased or tapped threads are used on die castings, and they involve, of course, secondary operations.

Most die castings need some machining but only light cuts are commonly required. The cost of such machining as is needed is always added to piece cost, but total cost on the parts here shown is presumed to be lower than for equivalent screw machine products, else the purchasers would hardly have chosen the die cast product.

Captions for each illustration refer to distinctive features of design and construction and are intended to indicate why the die castings were chosen, though particulars in this regard have not been sought from the user since, in most instances, neither the name of the user nor the precise character of use is known to the author.

for HIGH STRENGTH

at low temperatures



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Alloy	Temp. °F.	Tensile Strength, p.s.i.	Elongation % in 2 in.	Impact Resistance, Kg-m per sq. cm.
Electrolytic Tough Pitch Copper (Cold Rolled Strip)	68	58,700	8.4	6.6
	-295	64,800	11.2	7.4
Yellow Brass (Cold Rolled Strip)	73	85,400	6.3	8.1
	-295	102,900	10.1	9.4

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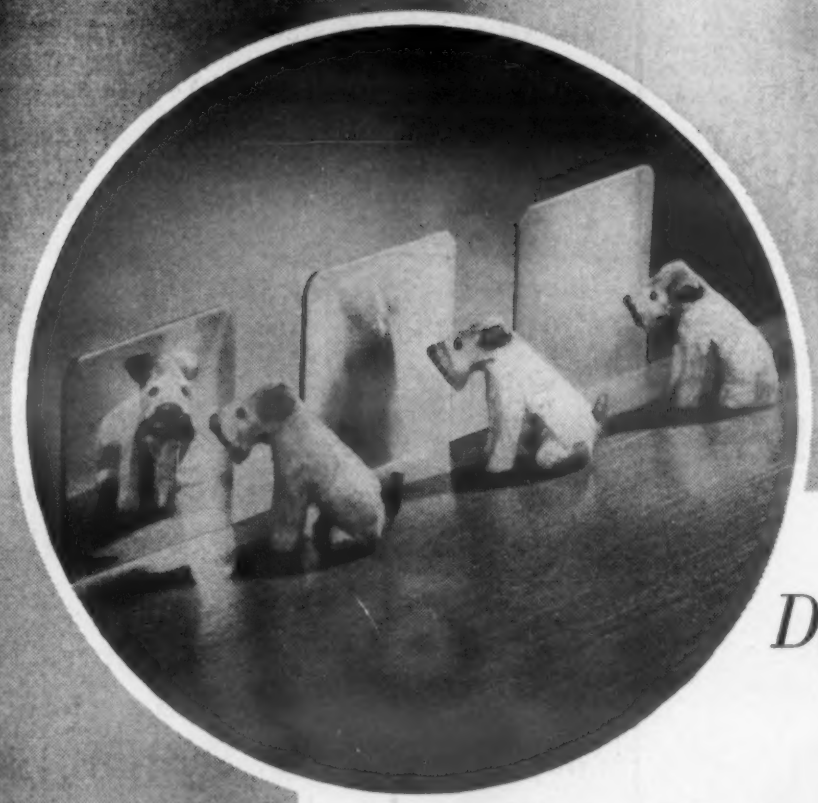

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MATERIALS & METHODS MANUAL

31

This is another in a series of Manuals on engineering materials and processing methods, published at periodic intervals as special sections in Materials & Methods. Each of them is intended to be a compressed handbook on its particular subject and to be packed with useful reference data on the characteristics of certain materials or metal forms or with essential principles, best procedures and operating data for performing specific metalworking processes.

Resistance Welding

by R. T. Gillette, General Electric Co.

Recent developments in resistance welding control, technology and equipment make possible the use of this fabrication method in almost any plant and on nearly any of the commonly used engineering metals. In addition to discussing the various types of resistance welding and their uses, the author points out ways in which such welding can be applied most economically. Where and when to use standard or special equipment is also discussed thoroughly to aid in making intelligent equipment selections.

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Introduction

Resistance welding is the art or science of uniting metallic parts, by heating surfaces of the parts to be joined by the opposition of the metals to the passage through them of an electric current, then allowing the metals to flow together assisted by pressure.

Resistance welding was discovered by Prof. Elihu Thomson early in 1877 when he discharged a Leyden battery through the fine wire secondary of a Ruhmkorff coil with the coarse wire of the primary terminals in contact with each other. A flash occurred at the point of contact and the wires were securely welded together. This suggested to him the possibility of resistance welding and later, perhaps in 1885 or 1886, he built the first resistance welder on which patent No. 347140 was issued Aug. 19, 1886.

So thus was born in a small way the process of metal fabrication we know today as "resistance welding" with its many modifications and subdivisions of procedures and equipment.

Types of Resistance Welding

Spot Welding: A resistance welding process wherein the fusion is confined to a relatively small area of the lapped work arts to be joined by the shape or contour of one or both welding electrodes. The minimum amount of marking will result on one side by using a flat electrode on the side where the least marking is desired and a domed or reduced area electrode on the other.

Projection Welding: A resistance welding process wherein localization of heat between two or more surfaces or between the end of one member and the surface of another is effected by projections.

Seam Welding: A resistance welding process wherein overlapping or tangent spot welds are made progressively, usually by one or more wheel or disk type electrodes.

Flash and Upset Welding: A group of resistance welding processes wherein the weld occurs simultaneously over the entire contact areas of the parts being joined.

While these four basic types cover in the most simple way the fundamentals of resistance welding, there are many variations and combinations of them. The various methods and equipment also have wide application in annealing, brazing, soldering and other allied metal working processes.

Basically, all types of resistance welding are the same with the possible exception of flash welding where part of the heat can be produced by arcing or expulsion of incandescent metal. This is a method of applying heat (electric current) and pressure under accurate control and can be expressed by the simple formula $H = I^2RT$ where H = heat, I = current (amperes), R = resistance (Ohms), and T = (time). It is important that this formula be kept in mind, as it controls resistance welds in all cases. It is of particular value in explaining what happens in welding dissimilar metals having widely differing electrical resistance where heat balance must be obtained between the parts being welded.

Materials That Can Be Resistance Welded

The metals and alloys which can be fabricated by resistance welding would consist of a nearly complete list of all engineering metals available. Many materials weld with ordinary equipment and procedures, while others require specialized equipment and close adherence to carefully worked out welding schedules. This is particularly true when welding dissimilar combinations of some of the highly specialized alloys developed for a particular engineering project.

Low Carbon Steel

The fabrication of standard low carbon steel sheet, plate, rod, and wire into thousands of every day articles constitutes the largest application of resistance welding. When the carbon content is kept at a maximum of 0.10 to 0.15% no difficulty is experienced from hardening. In the welds when the carbon is above 0.15%, various post welding heat treatments may be applied automatically in welding machine. (See section on controls for resistance welding machines.)

Low carbon steel can be spot welded in a range of sheet or plate thickness from 0.001 to 1 in., seam welded from 0.001 to about 0.375 in., projection welded from 0.010 to about 0.500 in., and flash welded from 0.015 to 4 in., depending on having available the proper welding equipment.

Low carbon rod or wire can be cross wire or projection welded in diameters from 0.002 to 1 in. or larger; flash or upset welded from 0.004 in. to a size limited only by the size of welding machine available. A flash welder has been built to weld a shaft 10 in. in dia. Spot or seam welding is not adaptable to welding wire or rod.

Starting with strip steel stock, or skelp, resistance welding of a finished tube is a well known process. Tubing can be butt or butt flash welded, and projection or seam welded to sheet or plate for various heat transfer devices.

Proprietary and Low Alloy Steels

Proprietary steels and many other low alloy steels weld in a manner quite parallel to that of low carbon steels except that when their alloying constituents cause hardening from welding they must be post heat treated in the same manner as high carbon steels.

Heat Treatable Steels

Steel in this classification can be welded by all of the resistance welding processes but welding must be followed by some type of heat treatment to prevent subsequent cracking.

When spot welding, such steel can be fully heat treated in the spot welder. The same treatment holds true for projection welding. (See section on controls.) Seam welds can be post heat treated in the seam welder in some cases, in others they require subsequent heat treatment in a furnace. Upset and flash welds can be given a post anneal in the welding machine and in some special cases a complete heat treatment. However, the generally accepted practice is to post heat treat in a furnace. As an example, manufacturers of tools such as drills, reamers, end mills, and the like usually post heat treat in a furnace when these tools are made with the cutting part of high alloy steel section provided with a low alloy shank. The tools are taken direct from the welder while still hot and placed in a furnace for heat treatment. If allowed to cool to room temperature, strains are set up which might cause cracking. The welding range of material in the high alloy steel classification is about the same as for low carbon steel.

Stainless Steel

Steels under the stainless classification usually weld very well. However, they have properties peculiar to themselves which must be recognized. They have high electrical resistivity which usually means lower current value for welding.

They have high strength at high temperatures which means higher pressure or electrode force. They have highly refractory oxides which means careful cleaning before welding. Some are susceptible to carbide precipitation if heated too long and require welding in as short a time as practical. A few of the stainless alloys, particularly the straight chromium irons, may harden somewhat in welding. It is possible that they might be post heat treated in the welder but there is no definite information available as to just what is required. Stainless steel can be welded by all the resistance welding processes in practically the same range as low carbon steel and are considered as having excellent welding properties. They require close control of all welding factors and the welding machines should have synchronous precision electronic control. (See section on controls.)

Welding Stainless to Carbon Steel

This combination welds quite readily if the proper procedure is used and all the welding processes are adaptable in most any range practical in carbon steel.

The major difficulty in welding stainless to carbon steel is that the stainless may have three to eight times the electrical resistivity of carbon steel and as the same current must be used to weld both pieces, the stainless has a tendency to overheat before the low carbon is hot enough to weld. This difference can be compensated for in different ways. In spot welding, an electrode of larger contact area is sometimes used on the stainless than the one contacting the low carbon. Perhaps a ratio of two or three to one will give a heat balance. In projection welding, where possible, it helps to put the projections on the carbon steel part. In seam welding, a wheel with wider face is used on the stainless side. In upset or flash welding more low carbon than stainless should protrude from the clamping jaws. There is no available tabulated information on obtaining this heat balance, but a few trials along these lines are usually sufficient to establish the proper procedure for a given job.

Alnico

While it is possible to resistance weld parts to alnico, the welds are not satisfactory. Due to the particular crystalline structure of alnico the heat effected zone pulls out of the adjacent alnico adhering to the part welded to it. In some cases it is possible to cast small low carbon inserts into the alnico to which other parts can be spot or projection welded.

Aluminum and Its Alloys

Aluminum can be spot, seam, upset and flash welded successfully. Little success, however, has been achieved in projection welding it. Due to the high electrical and thermal conductivity of aluminum welding equipment of high energy, output and synchronous electronic precision control are necessary to produce a consistent high quality product with a minimum of rejects. The moving element of these machines should also be kept as light as practical to eliminate the inertia factor and be as free from friction as possible to allow rapid follow-up for forging action as the metal softens.

Aluminum has the inherent characteristic of building up a film of oxide of high electrical resistance which must be removed either by pickling or wire brushing before welding. The material should be welded within three to five hours after cleaning or the oxide film will reform and necessitate recleaning.

It is not possible to determine the presence of this oxide film by visual inspection. The only sure way is to take surface resistance measurements.

The surface resistance for successful spot or seam welding should be in the neighborhood of 20 microhms. Surface resistance on improperly cleaned metal may be several hundred microhms and vary in different parts of the surface by several hundred microhms. Simple equipment for measuring surface resistance is available. The cleaning for upset or flash welding is not so critical as for spot or seam welding but should not be completely neglected.

Brass

The brasses (with the possible exception of brass high in lead which may give brittle welds) weld quite well by all of the resistance welding methods. High brass or brass with high zinc content, due to its higher electrical resistance, will weld somewhat better than low brass with its high copper content.

Compared to welding steel the current should be somewhat higher, time shorter, and pressure lower. If pressure of too high a value is used it may cause cracking in the zone adjacent to the weld due to the hot short characteristics of some grades of brass. If excessive welding time is used it may vaporize a considerable amount of zinc from the zinc bearing alloys with some change in the properties of the material in the weld area.

For consistent welding, brass must be carefully cleaned as the complex oxide does not break down readily between the faying surfaces so that the metal of the two pieces may flow together and form a weld. The electrode contacting surfaces will vary in resistance over a wide range in different places on the same work piece. The

combined action of these two factors will cause erratic welding.

Brass of different thicknesses or different composition will weld in dissimilar combinations. The range of sheet thicknesses of brass which can be practically spot welded will run from 0.005 to about ¼ in. Beyond this range the size of equipment and the current demand become excessive.

Projection welding from 0.010 to 3/16 in. is practical; seam welding from 0.001 to about 3/16 in.; upset or flash welding from 0.005 dia. to approximately 2 in. dia. beyond which size, equipment and power demands become excessive. The welding machine and control settings for brass are rather critical and the equipment should be accurately built with adequate electrical and mechanical capacity and synchronous precision control.

Bronze

The term bronze covers a wide range of alloys, many of which are available in the form of sheet, rod, tubing and wire. The major portion of the bronzes weld quite well, the exception being those containing lead and some of the high copper bronzes which have high heat and electrical conductivity. Spot, projection, seam, flash, and upset welding can be applied to sheet. Rod and wire can be cross-wire or projection-flash and upset welded and some types of tubing construction permit all types of welding.

The welding equipment and procedure is comparable to that used on various types of brass, requiring accurately built machines, high electrical capacity and precise timing.

Careful attention must be given to the proper cleaning of these alloys prior to welding so good electrical contact is obtained between the electrodes and sheet and so there will be no oxide on the faying surfaces to interfere with the metal flowing together as the weld is formed.

The silicon type of bronze has the best welding characteristics, welding nearly as well as low carbon steel. Phosphor bronze is a close second and practically all other bronzes can be welded if a carefully planned welding schedule is worked out and adequate equipment is available.

Cast Iron

There has been little application of resistance welding to cast iron as the localized heating usually causes cracking of the material. However, by preheating in the range 1200 to 1400 F some spot welds have been made on sections up to ¼ in. thickness. A few applications have been made where thin low carbon or stainless steel sheet has been seam or spot welded to cast iron without preheating. However, the operation is critical.

Copper

Spot, projection and seam welding of copper is not practical due to the materials high electrical and thermal conductivity and lack of plastic or weldable range below its actual melting point.

Upset or a modified flash upset welding method where a short initial flashing period, to give a good clean surface, is followed by a regular upset weld cycle has been used for many successful applications. One instance is welding rings from various sizes of rod, bar or wire. Welding of copper wire in the wire mill is done to give continuous lengths for drawing so that the dies do not have to be threaded for each coil of wire and to give definite lengths of finished wire.

Special equipment is available to flash upset weld copper wire from 0.010 to 1 in. in dia. or equivalent cross section of other shapes.

Beryllium Copper

Beryllium copper, which should probably be classified as a bronze, is weldable by all the resistance welding methods. Welding is critical requiring careful cleaning and mechanically operated welding equipment with synchronous precision control and a carefully worked out welding schedule. Many other copper alloys not listed as brass or bronze can be welded, excluding those with any appreciable amount of lead. The list of such copper alloys is too long to treat each one separately. However, a study of the properties of a particular alloy usually indicates if there is a possibility of its being welded. If an alloy has several times the electrical resistance of copper and has hot forging properties, there is a good probability that it is weldable.

Coated Metals

Coated metals such as galvanized iron, aluminum coated steel, tin plate, tern plate and cadmium plated steel in sheet, rod and wire can be welded by all resistance welding methods. In general, such materials require more time, current and electrode force than uncoated steel. Electrode pick-up is a common difficulty with these materials —that is, the coatings melt at the welding temperature and alloy with the electrode contacting surfaces, causing high contact resistance. The electrodes must be cleaned of this pick-up frequently, if satisfactory welding is to be expected.

There is some loss of corrosion resistance in the weld area, and considerable marking and discoloration is to be expected. When welding these materials toxic fumes may be produced and good ventilation should be provided. Many of the proprietary coatings such as Calorizing, Parkering, etc. can be welded unless their surface electrical resistance is too high or the coating alloys readily with the base metal to form a brittle alloy.

Careful attention should be given to proper cleaning of these materials to remove grease, dirt, and, where possible, oxides. These materials usually require welding equipment of higher electrical capacity and more pressure or electrode force than the uncoated steels.

The classification of coated metals should include the electroplated as well as hot dipped material and, in general, the same procedure is followed. In some of the hard high resistance coatings like chromium plate most of the plating will burn away although one side may be somewhat protected by using a large flat electrode on the side where the best finish is required and the standard dome or reduced size electrode contacting the other side.

To obtain a sound weld on any of the coated or plated metals requires that the coating be melted on the faying surfaces and high enough pressure be applied to force the coating aside and form the weld between the pieces of base metal. If the coating only is melted, a soldered joint, not a weld, results.

Clad Metals

Clad metals, like stainless clad, nickel clad, Monel clad, and copper clad steel will weld satisfactorily with the possible exception of copper clad, when the percentage of copper to steel is too high.

No special precautions are necessary except good cleaning and adequate welders and control.

The procedure will be primarily controlled by the type of cladding; whether clad on one or both sides, or if a clad or unclad surface is to be welded to a like member or to a dissimilar member.

Gold

Gold and most of its alloys can be welded by resistance, spot, projection, seam and upset welding. The use of gold is so restricted that little information is available except in the jewelry trade.

Lead

Lead is weldable by resistance, spot, projection, seam and upset welding. However, due to its low melting point and extreme softness at room temperature, equipment incorporating low electrode force, low electrical capacity, designed with light weight moving parts to give quick follow-up or forging and electronic control giving precise control of welding current is required. The material must be cleaned carefully within as short a time as possible before welding to insure consistent results.

Magnesium

Magnesium and its commercial alloys are weldable by spot, seam and butt welding. Projection welding has not been successfully used as yet for welding magnesium.

The welding procedure, equipment, control, cleaning and processing for magnesium quite closely parallels that used for aluminum.

The welding machines should be of high electrical capacity, provide medium high electrode force, and have light weight low inertia moving parts for fast follow-up or forging pressure. Synchronous precision electronic control is a must for welding magnesium. Because of its relatively low melting point, high electrical and thermal conductivity and general sensitivity, it must be welded with short time and high electrical input.

Alternating current welding equipment is satisfactory when plenty of power is available. When there is a question of power supply, the stored energy type of welding equipment can be used satisfactorily.

Nickel

Nickel and its more common alloys like Monel, inconel, and nickel silver are among the readily weldable materials that can be welded by all the resistance welding methods. Compared to steel it has slightly lower melting point and lower resistance. Interpreted into welding terms, it would require a little higher current density and higher pressure.

The welding equipment used for welding nickel and its alloys should have low inertia moving parts to insure quick follow-up of welding electrodes as the parts being welded reach the welding temperature and must be equipped with synchronous precision electronic control.

Platinum

Platinum welds readily by spot, projection, seam or upset welding. As most parts made of platinum are relatively small, the equipment for welding must be scaled down accordingly and accurately controlled. Alloys of platinum containing iridium, osmium, palladium, or other rare metals usually weld as well as straight platinum. As an example, platinum iridium or other alloys used to tip fountain pens are being projection welded to the pen nib successfully. Also, in the manufacture of electronic tubes of many kinds all sorts of combinations of rare metals and alloys are being successfully spot, seam, projection and upset welded.

Silver

Although silver has low electrical resistance it can be successfully resistance welded by spot, projection and upset welding. Little success has been achieved in seam welding and the major portion of the welding has been on relatively small sections such as fine wire, thin sheet. Such welding is primarily of electrical contacts for many types of electrical control devices. In welding these contacts projection welding is usually employed. Many silver contacts are formed with projections and are usually welded to other materials such as copper, phosphor bronze, brass, beryllium copper, etc. Where large heavy sections of silver are to be joined to like or dissimilar metal combinations, resistance brazing or silver soldering is usually employed.

The equipment used to weld silver must be of relatively high electrical output and have low inertia moving parts with synchronous precision electronic control to insure welds of good quality.

In many cases electrodes faced with tungsten or molybdenum are used to weld silver since they have relatively high electrical resistance and low heat conductivity and assist in putting heat into the weld area while conducting little heat from the weld.

Tantalum

Tantalum is weldable by the resistance welding methods if certain precautions are taken. The metal is likely to absorb various gasses if welded without some protection. It is frequently welded immersed in water or carbon tetrachloride.

Tungsten and Molybdenum

Tungsten is difficult to resistance weld due to its high melting point and the rapidity of oxidation at high temperature in air. It also recrystallizes when heated to high temperatures forming a brittle zone to the weld area.

Tungsten does, however, weld quite well to nickel, the nickel wetting and flowing around the tungsten at the melting point of nickel.

Molybdenum can be spot, projection, seam and upset welded. There is some tendency for grain growth in the area of the weld which may reduce the strength and make the weld area slightly brittle.

Molybdenum should be welded with short time and high energy input as trouble with oxidation may be experienced at its high temperature welding point if long time is used.

Molybdenum also welds readily to nickel, and, with special procedures, to some other metals.

In welding tungsten and molybdenum use is sometimes made of percussion welding, a direct condenser discharge across the parts being welded which gives an extremely short welding time at high current level. This method is limited to small sections or wire about ⅛ in. in dia.

Tungsten and molybdenum must be carefully cleaned to remove all oxides before welding.

Tin, Bismuth, Antimony, Cadmium, Tellurium and Beryllium

So far as can be determined very

little welding has been applied to this group of metals. There seems to be no good reason, however, why they could not be resistance, spot, projection, seam and upset welded if properly designed equipment and control were employed and proper welding schedules were worked out. To date there seems to be very little interest shown or requests made for welding this group of metals. If structures are designed to require welding of metals in this group, it seems logical to expect that methods of welding them could be found, using resistance welding equipment as developed today.

Zinc

Zinc and zinc base die cast material weld satisfactorily by spot, projection, seam and upset welding. There is some evidence of coarse grain structure in the weld area which may cause the metal in the area of the weld to have slightly less strength than the sheet in the as-rolled condition, but the welds are generally satisfactory. When welding zinc, low electrode force must be used or electrodes will penetrate completely through the material, the current is much lower than when welding steel and the time is longer. Synchronous precision control is a must when welding zinc as it is necessary to prevent the molten metal from coming to the surface, lest the entire weld area will be expelled leaving a hole through the sheet.

Electrodes should be thoroughly water cooled to reduce to a minimum zinc pick-up on the face of the electrode. Zinc pick-up on electrodes must be cleaned off frequently or electrodes will stick to the work.

Material must be clean and free from grease, oil or oxide.

The use of pulsation welding helps control the weld nugget (see section on welding control for description of pulsation welding).

The use of various types of resistance welding should help in fabricating structures difficult to die cast in one piece.

Dissimilar Metal Welding

The resistance welding of various combinations of dissimilar metals is finding ever increasing use, particularly in the electrical industry. All types of welds are used.

While many dissimilar combinations require no more care than used when welding similar materials, other combinations may require special care or procedure to be successful.

Some of the factors pertinent to successful welding of dissimilar metals will be pointed out. The particular combination to be welded should be studied from a metallurgical standpoint to determine what type of alloy will be formed in the weld and whether it will be brittle or will have sufficient strength and resistance to shock for the particular application in view.

It may be possible to weld a given combination which forms a brittle alloy by one method and not by another. An outstanding example of this is in welding copper to aluminum. This combination normally forms a brittle alloy when spot or seam welded, and to date no method has been developed to overcome this difficulty.

However, a very successful upset welding method has been developed to weld copper to aluminum. Briefly, this is accomplished by using as light a pressure as possible and still not get arcing during the heating period. Just as the current is cut off when the proper temperature is reached, this pressure is increased by several times. The brittle alloy is completely extruded from the weld, leaving a sharp line of demarcation between the two metals in the weld. The resulting weld is ductile and entirely satisfactory.

In making this copper-aluminum weld, another problem common to dissimilar metal welding is encountered—that of heat balance. As the same current must be used to heat both metals and copper has both a higher melting temperature and lower electrical resistance than aluminum, it would be expected that the aluminum would reach the welding temperature sooner than the copper. A heat balance is secured in this case by allowing about five to six times as much copper as aluminum to protrude from the water cooled upset welder jaws. The water cooled dies will then retard the heating of the aluminum much more than the copper, and the welding temperature of the two metals will be reached simultaneously.

When spot welding combinations of dissimilar metals of widely different electrical resistance and/or melting point, another method of obtaining heat balance is frequently used. That is, by using electrode material of different resistance. As an example, if we wish to spot weld copper to steel and were to use electrodes of the same material contacting both the copper and steel, the steel would melt before the copper was hot enough to weld. To give the proper heat balance, a high conductivity copper alloy would be used on the side contacting the steel. An electrode faced with tungsten adds some heat to the copper but does not conduct away heat generated by the current passing through it while the copper alloy contacting the steel retards the heating effect enough that both parts come to the welding temperature at the same time.

There are many different electrode materials available with resistance varying between copper and tungsten to give the proper heat balance between combinations of dissimilar metals with less difference in resistance and/or melting point than the copper steel combination. Another method sometimes used to obtain heat balance where there is a small difference in the combinations being welded is to use an electrode of somewhat smaller contacting area on the material having the lowest resistance or highest melting point than the electrode contacting the material having the highest resistance or lowest melting point.

Dissimilar metal combinations of sheet, plate, rod, wire, tubing, various formed parts such as studs, screws, disks and others, as well as composite metals like the various clad metals in sheet wire or rod, thermostatic strip, and with few exceptions all of the special complex alloys are weldable in hundreds of dissimilar combinations.

Advantages of Resistance Welding

The simplicity of parts and their preparation for resistance welding is a strong point in favor of using this method of fabrication.

When properly designed parts are resistance welded with equipment adapted and tooled in a suitable manner for the job, it is by far the most economical method of welding.

Highest speed or greatest production per operator can be obtained by this type of welding.

With proper procedure and maintenance of equipment, resistance welding will give a consistently high quality product. As there is no filler material added in making resistance welds, there is no opportunity to contaminate the weld with the addition of a material which might have some undesirable properties in a particular application.

Fluxes are never used in resistance

welding which eliminates the problem of flux removal and flux corrosion.

The heat required to make resistance welds is confined in large part to the actual area of the weld itself, which keeps distortion to a minimum. When skilled setup men and supervision are available, iittle training is necessary for resistance welding machine operators.

Parts of much smaller size can be welded by resistance welding than is practical by any other welding method. (Parts so small that they have to be assembled under a microscope are being welded successfully.) Superior results are obtained by using the resistance method of welding for various combinations of dissimilar metals, difficult to weld structures of widely different cross-section or area, and precious metals, than by other methods.

Limitations

Some limitations on resistance welding are high initial cost of equipment as compared to arc or gas welding equipment, lack of ready portability, and impracticality for such uses as building or bridge erection and ship building, although many sub-assemblies can be fabricated in the shop for these large structures. Resistance welding machines are not as versatile as arc or gas welding equipment, although many general purpose machines are in use. Resistance welding is not practical for welding the heaviest metal sections available.

Design for Resistance Welding

The importance of proper design for resistance welding is frequently overlooked or given secondary consideration.

A general knowledge of the fundamentals involved in resistance welding, the equipment available, or special equipment which can be built, including jigs, fixtures, and holding and locating devices, is essential if parts are to be designed to be fabricated at low cost and of consistently high quality.

That a product has been successfully built by riveting, soldering, brazing, bolting, etc. is no criterion that it is well designed for resistance welding. Frequently minor changes in design, when changing from one method of fabrication to another, will give a considerable reduction in cost. One of the first considerations in designing for spot, seam, or projection welding is to make sure enough overlap is allowed to support the molten metal in the weld nugget to prevent expulsion.

Parts should be so designed that all welds are accessible to a single standard setup on a machine, since each time a part has to be changed to another jig or fixture or the set up changed the cost of welding is increased.

When designing for projection welding, care must be taken to locate the projections where they will develop maximum strength in the weld. Where parts of different thickness are to be projection welded, it is good practice to form the projections on the heavier part. If the projection is on the lighter part it may collapse before the heavier part becomes hot enough to make a weld, again a question of heat balance.

Projections are usually designed so they give a point or line contact, then have a continuously increasing cross section to the full area of the weld.

Several companies making bolts, nuts and screws make special bolts, nuts, screws, studs, pads, etc. specially designed for projection welding.

When designing for flash or upset welding the butting parts at the weld line should be of the same shape and area and the structure designed with contours and sufficient surface to facilitate clamping in the welder.

Material like wire, rod, bar, tubing and various structural shapes which are flash or upset welded automatically give the proper abutting surfaces and plenty of clamping area.

Where possible, it is of value to make either scale models or full size parts when various structures are being designed properly to prove the accessibility of various welds on available equipment. When it is not possible to make a full scale part of metal by hand a scale model of heavy paper stapled together at the location of each weld makes a good model to study. This will often suggest a much simplified design, and simplicity of design helps to reduce cost.

Resistance Welding Equipment

There are several points common to all welding equipment which merit careful consideration when purchasing resistance welders. A study should be made of the specific job at hand to determine the best type of machine available for the particular job. Also, keeping the over-all plant situation in mind, it should be determined if the particular job is likely to run several years or only a few months, if the equipment chosen is adaptable to other types of production, or if it becomes obsolete when the particular part for which it is chosen becomes obsolete, or is redesigned.

Should a welding machine be as nearly standard as possible or should a special machine be built for a specific asembly must be decided. Where sufficient production is expected on a certain assembly, a special machine can be amortized during the production life of the assembly for which it is designed. The special machine can give five to twenty-five times the production of a standard machine with the same labor cost but might not be adaptable for any product other than the one for which it was designed and still prove to be the cheapest in the over-all cost program. The design of welding machines follows quite closely the design of machine tools with the addition of the proper electrical and mechanical devices to heat and squeeze the metal being welded in the appropriate sequence.

Consideration should be given primarily to the cost of production rather than to the first cost of equipment. The welding machines should be chosen with excess electrical and mechanical capacity rather than with just enough to get by, as with a small change in design or increase in metal section a little more capacity is good insurance that the equipment can do the job and not overload electrical and mechanical parts. There is no universal equipment for resistance welding (such as a torch for gas welding). For example, we could not make a seam weld on a flash welder or a flash weld on a seam

welder. Nor can we expect to spot weld two pieces of ½ in. thick steel on a spot welder designed to weld two pieces of 0.010 in. steel. However, when production and set-up speed can be sacrificed, machines of relatively large range are available for job shop work. Equipment for all types of resistance welding should be automatic at least to a point where it eliminates the human element so far as time of making a weld is concerned. This would mean some type of mechanical drive rather than foot or hand operation. With manual operation it is possible for an operator to beat the timer even when electronic timers are used. Timing on manually operated equipment is responsible for more erratic and poor quality resistance welding than any other factor and holds true on all types of welding.

The mechanical drive of resistance welders is applied in many forms. They can be powered with a motor driving through a speed adjusting device and have a spring or air cushion for the electrode pressure or force; air operated with many types and combinations of air cylinders to get adjustment of electrode force or pressure; or, on large or some special machines, hydraulic operation and electrode force or pressure methods may be used. Some welders are equipped with dual electrode force or pressure using light pressure during the current flow period and a heavy forging or upset pressure to complete the weld.

We will discuss briefly the equipment used for each type of resistance welding.

Spot Welding Machines

Spot welding is no doubt the most widely used type of resistance welding and has the widest variety of equipment available over a large range of types and sizes. While much manually operated equipment is available the advisability of its use except in the case of small bench welders operating in very short time is questionable, so only mechanically operated machines will be considered.

Standard spot welders are available in sizes ranging from a ½-kva. motor operated machine to those of 1500- to 2000-kva. capacity of the air operated type. Large welders are usually air or hydraulically operated although motor operated equipment is available. While it is not possible to make multiple welds by using two or more electrodes in parallel on a standard welding machine due to uneven current distribution to the parallel electrodes—spot welding machines with many pairs of electrodes are in use. Various trade names are given these welders. One system uses one common welding transformer on the machine and a hydraulic cylinder for each electrode assembly. These electrodes are brought in contact with the work one at a time and controlled by a rotating hydraulic valve. In another type all electrodes are brought in contact with the work simultaneously under pressure, the secondary current is commutated from the transformer to each welding electrode and pressure assembly in sequence, the current being switched off between contacts and turned on as the commutating device reaches the next electrode assembly.

This type of equipment has been built with as many as 180 electrode assemblies. While high-speed welding can be accomplished with this type of spot welder, they are, of course, special purpose machines and must be completely rebuilt or scrapped when changed from one job to another. Even so, they are justified since they produce low cost, high quality assemblies at high speeds as they eliminate handling to position each weld while placing many welds in all parts of the assembly.

The use of the so-called spot welding guns or semi-portable spot welders is frequently necessary on large assemblies like bus, truck and automobile bodies, large enclosing cases and other structures too large to be positioned on standard welders or not adaptable to multimatic or hydromatic welders.

Gun welders usually are hung from the ceiling or some type of hoist or crane on a balancing unit with the gun connected to the transformer with water cooled concentric cable. While the standard welder has greater over-all efficiency and should be used where possible, the use of gun welders is to be encouraged on assembly work.

On very large structures like railroad cars, locomotive parts, and large building panels, crane type of welders arranged for spot, projection and seam welding are sometimes used to advantage. Crane welders operate on the so-called series method where both electrodes are on the same side of the work. When welding reinforcing members to flat sheets one electrode is placed on each of two reinforcing members and two spot welds are made simultaneously. These welders are so arranged that the spacing and position of the electrodes can easily be varied.

The electrodes, secondary windings of transformers, fixtures, gun welder cables and all high-current carrying parts of spot welders must be carefully water cooled to prevent overheating and give high-speed continuous operation.

It is advantageous to have all contacting surfaces of bolted joints in the secondary electrical circuit of all welders silver plated to give low contact resistance and prevent oxidation in service.

For spot welding aluminum, magnesium and their alloys, the stored-energy type of spot welder is well suited, as the line current demand is lower. Power is taken from the line at a low rate and long time and discharged to make the weld in a short time at a high current rate. Two types of stored energy welders are available, the magnetic stored-energy type which builds up a charge on a special reactor and the capacitor stored-energy type where the energy is stored in capacitors. Whichever system is used, the end result from a welding standpoint is comparable.

Projection Welding Machines

Projection welding can be done on spot welding machines by using a different type of electrode construction. When making spot welds, electrodes with a flat or domed reduced area contacting surface are used to localize the current over the area of the weld. In projection welding the current is localized by the projections and large flat electrodes or electrodes made to form a fixture fitting the parts and locating the two or more parts of an assembly in their proper relation can be used. Projection welding machines, while of the same general construction as spot welding machines, must be carefully constructed and should be of the press type rather than the rocker arm type so that the electrode force or forging pressure can be applied in a straight line rather than in an arc.

Projection welds generally require shorter welding time with higher electrode force and higher current input than do spot welds.

The lower arm on welding machines used for projection welding should be rigidly constructed to prevent deflection which might cause two parts to weld together at an angle instead of

retaining their parallel relation. The concentric type of spot-projection combination welding machine is particularly free from angular deflection and has a concentric secondary welding circuit which gives a relatively low primary current demand.

The concentric welder is particularly adapted to spot or projection welding on parts of relatively thick cross section when their other dimensions are not too large to be welded on this type of machine.

Seam Welders

As a seam weld is really a series of overlapping spot welds, the equipment is comparable up to a certain point. In seam welding the regular spot welding electrodes are replaced by two disk or wheel electrodes—one or both driven by a motor and variable speed drive, or in some cases both wheels idle and the work pulled at a constant speed between the two disk electrodes.

Special electrodes coupled with the proper current interrupter or control which rapidly turns the current on and off makes a series of overlapping spot welds which gives a water or gas tight seam weld.

Where long straight rows of spot welds are required, they can be made by a seam welder. In this case the control gives a short current application and a long off period. By applying the proper off and on time relation spot welds may be made with any desired spacing. These are usually called roll spot welds.

Many seam welding jobs require specially designed machines. Such a machine was designed for welding a stainless steel refrigerator evaporator. In this machine hydraulic drive is used to pull the work between the wheels with wheels idling. Four welds are made simultaneously, using two transformers with each pair of wheels in a series circuit. Another seam welder, making 10 seams at one time, was designed to weld a refrigerator condenser having 20 parallel seams each about 46 in. long. The production on this machine was roughly 20 times that of a standard seam welder.

Most seam welds are made either immersed in water or with streams of water, one before and one after the wheel contact both top and bottom, at the point of contact between wheels and work. Water prevents rapid electrode wear, annealing of electrode contacting surfaces, over-heating distortion, and excessive oxidation of work parts.

All secondary current carrying parts of seam welders must also be carefully water cooled as high current densities are used with a high duty cycle. The current on-time on a seam welder can be as high as 80% while spot welders are seldom above 10% current on-time.

When specifying seam welding equipment a careful study of both the part to be welded and the welding machine should be made to be sure that the seam is accessible without interference from some machine or work assembly part.

Seam welding machines must be sturdily built with sufficient electrical and mechanical capacity for the assembly planned.

Butt Welders

There are two classes of butt welding. In upset welding the full upset pressure is applied to the work parts after clamping in electrodes; then the current is applied for a sufficient length of time to heat the work parts to the welding temperature by resistance only, the pressure completing the upset or forging at the same time. Current is cut off as the forging is completed.

Second is the flash weld where parts to be welded are clamped in the electrodes with the ends to be joined not quite touching. The parts are then moved towards each other until they do touch. An arcing and expulsion of metal ensues. The parts are kept moving towards each other at the correct speed until the proper welding temperature is reached. Then the forward motion is accelerated for the forging or upset action. The current is switched off at the start or shortly after the start of the forging action. In this case, the heating is caused by the combined action of resistance and arcing.

Both classes of welds can be made on the same welding machines by changing the method of operation, or different types of machines can be used.

While manually operated flash-upset welders are available, mechanically operated welders are preferred as they give more consistent quality.

Flash-upset welders are constructed using manual spring, motor gear box and cam, air or hydraulic upset mechanisms. The kind of material, size of section, amount of production and geometry of the part to be welded determines the method and type of welder to be used.

For upset welding small cross-sections and many of the nonferrous metals spring upset welders are used. Wire as small as 0.004 in. has been welded in one spring welder and its range is up to about 0.015 in. Similar welders are available for welding up to 1 in. dia. copper wire or rod.

For large production on medium sized parts of steel of all kinds, nickel and its alloys, some of the aluminum alloys, brass and bronze, the motor gear and cam arrangement is generally used. This type of welder is used for welding tanks, barrels, cams, metal boxes, and similar products.

Where large sections are to be flash welded the hydraulic operated flash welder is used. One such welder has its own two-stage hydraulic pump. One stage for the clamps and the other stage for welder platen travel and weld upset. This welder is fully automatic. Any part of the following procedure can be used: preheat, flash, upset, and post heat. It will weld section up to 6 sq. in. Welders of this class have been built capable of welding sections up to approximately 80 sq. in., in low carbon steel. It should be recognized that a welder of this size will require special attention to its power supply.

Percussion Welding

Percussion welding being limited to small cross sections finds a restricted number of applications, and is used primarily in wire below ⅛ in. in dia. The parts are clamped in the welder some distance apart, with the moving member locked in front of a spring of the proper design. A charge is then built up on a bank of condensers with sufficient energy to make the weld. The condensers are connected across the work parts. When the lock is removed from in front of the moving member of the welder, the parts move together rapidly. As they move near together an arc is formed which gives a thin surface fusion. Then, as the parts come together at high speed, the weld is forged.

Electrodes for Resistance Welding

The electrodes for resistance welders, unlike those used for arc welding, are not consumed as part of the weld. They do, however, wear and get out of proper shape so that they require reconditioning periodically and ultimately

must be replaced.

Electrodes should probably be classed as non-durable small tools, in the same class as lathe cutting tools, drills, reamers, and end mills.

An ideal electrode would have the electrical conductivity of silver and the hardness of tungsten carbide. Since no such material is available, a compromise must be made. Hard copper anneals too readily to make a good electrode material and it is too soft. As a start a good copper alloy for spot welding electrodes and seam welding wheels will have an electrical conductivity of about 75 to 85% of copper and a hardness of around 70 to 80 Rockwell B. Alloys of this type are made from various combinations of copper alloyed with cadmium, silicon, chromium, beryllium, cobalt, usually as binary or ternary alloys.

Some alloys receive their hardness from cold working, others are heat treatable. Caution should be used in making special electrodes or fixtures from these materials to see that no brazing or other high temperature method is used on them as they all anneal at relatively low temperatures and, once annealed, they are no better than straight copper.

The harder alloys of the above class are also used for projection welding electrodes and flash-upset welder dies in some instances. However, another series of alloys or metallic mixtures containing tungsten or molybdenum with copper or silver are available and are particularly adapted for projection welding electrodes and fixtures as well as flash upset welder dies. When these materials are used the entire electrode or fixture is seldom made from the one alloy. Copper or some one of the other electrode materials are faced with the chosen material on the contacting or wearing surfaces. These facings are usually in the range of ¼ to ⅜ in. in thickness.

Tungsten or molybdenum alloys have from 30 to 40% of the conductivity of copper and have a hardness of from 55 to 110 Rockwell B. All electrodes or fixtures must be thoroughly water cooled as near to their working surfaces as possible or their maintenance and replacement cost will be excessively high. A rise in temperature in the electrodes or fixture also has an adverse effect on the electrical conductivity of these materials.

It is difficult to give general recommendations for the proper electrode shape and material. Selection is controlled by several factors, including type of material being welded, geometry of the parts, whether like or dissimilar metals are being welded, and surface condition of work parts. Suppliers of electrodes and electrode materials usually can recommend the proper selection for a job in mind.

Jigs and Fixtures

The importance of jigs and fixtures for all types of resistance welding cannot be overstressed. They should be designed for accuracy, simplicity, ease of operation, accessibility for maintenance, and quick renewal of current carrying parts which contact the work pieces.

Nonmagnetic materials should be used throughout. Magnetic materials in the magnetic field of the welder will only run hot and decrease the welding capacity of the machine through their insertion in what is, in effect, a reactance coil. Care must be used in designing the fixture to insulate parts which might short circuit the welding current around the weld area. In some cases an entire jig can be constructed from one of the fabric base plastics. This is light weight, has no magnetic or reactive effect on the welder, will stay cool, and there is no insulation problem.

In the case of some of the multimatic, hydromatic or speedmatic welders, the entire machine becomes a jig with the addition of several hydraulic gun welder assemblies.

Resistance Welding Control

The control for resistance welding machines is really the brain of the machine, sending impulses that start a sequence of operations which end in the completion of a weld.

Suppose we follow the sequence of what happens when we make a spot weld on an air operated press type welder.

The operator closes a foot switch energizing a relay which opens an air valve bringing down the head of the welder until the electrode contacts the work and builds up a predetermined pressure controlled through an air pressure reducing valve. At this time another relay closes a switch initiating a pair of ignitron tubes which switch the welding current to the welder transformer for a definitely controlled time. After the flow of welding current ceases, the pressure or electrode force is held on the work part for a short time to allow the metal to cool below its melting point, then a relay opens a solenoid valve and the air is exhausted from the top of the cylinder and admitted to the bottom, raising the welder head and placing it in condition to start another weld cycle. These control sequences happen so rapidly that machines can make 100 or more welds per min. in some applications.

Before electronic control was developed for resistance welding, welder controls were rather crude and not always sufficiently accurate to give a consistent welded product.

The result was that few metals other than low carbon steel was welded.

In the early years of resistance welding when nearly all welders were manually operated, the only control was a simple push button switch. The electrical capacity of these welders was low and, because considerable time was required to make a weld, the operator tried to watch the color or feel when the metal forged together. Although considerable skill was developed by some operators, the quality of the weld was erratic.

With the development of mechanically operated welders the cam-controlled limit switch was used to actuate a solenoid-operated main switch applying current to the welder transformer. This control, which gave results far superior to the manual control, still left out many desirable features. It was nonsynchronous, applying current to the welder transformer at any point on the voltage wave which produced transient currents. This effect often burned the work pieces and resulted in high electrode maintenance.

When making seam welds the use of an interrupter rapidly making and breaking the current was necessary. Many types of mechanical interrupters were built. These were again non-synchronous and gave trouble with high maintenance and burned work.

All of these early control devices were slow in action and made welding in short times like one or two cycles on 60-cycle current impossible.

With the development of synchronous precision electronic control for resistance welding, the whole welding situation was changed.

Welding schedules with welding time ½-cycle or less (1/120 of a sec.) to as long a time as desired can be set up with exact duplication of time and other welding factors over any period time desired. This, plus elimination of current transients, makes possible the welding of metals and alloys impractical to weld with the earliest available equipment.

Synchronous Precision Electronic Control

Electronic welder controls have been developed for all types of resistance welding and welding machines.

In pulsation spot welding the current is applied intermittently with a definite on and off time (a typical welding schedule for pulsation welding might use six cycles on and four cycles off, repeated 10 times). Numerous combinations of on and off time and number of repetitions are available.

Electronic control, by synchronous switching the current to the welding transformer at the power factor angle or later, eliminates transients which may occur when current is switched at random in relation to the power factor angle. These transients may reach several times the steady current condition and, as was pointed out at the start of this paper, the heating effect varies as the square of current. It is quite evident that these transient current conditions will cause overheating and burning of electrodes and work parts.

One control is also used for a seam welding interrupter, switching the welding current on and off with the required number of cycles in both on and off time, repeating this indefinitely. The same synchronous principle applies whether the control is used for spot, projection or seam welding.

For flash-upset welding, the so-called ignitron contactor is generally used. This is a modification of the control described above and may or may not be arranged for synchronous switching. Both types of control are usually equipped with phase shift control for heat or current regulation. This is accomplished by switching the current to the transformer at a predetermined point later than the power factor angle. This gives current adjustment in infinite steps.

The controls so far described are adequate for welding materials which are not heat treatable. When welding heat treatable material, such as high carbon or other alloy steels, an auxiliary control, called a program control, is used in conjunction with the regular controls described to heat treat these materials after welding. By careful study of the S curves of the particular material being welded and setting up the proper heat treating schedule, parts fabricated from heat treatable material can be welded and given the proper heat treatment to leave the weld area in the same physical state as the balance of the fabricated structure. If the weld area was left in the as-welded condition, it would have the maximum hardness of the material in the fully heated and quenched state.

Instruments

Several instruments have been developed for the use of the welding personnel and their use should be encouraged.

They include: pointer stop ammeters with their current transformer for measuring welding current; various voltmeters for measuring line and welder voltage; recording volt and ammeters for studying line condition; electrode force meters to measure electrode force; oscilloscopes of various types to study and control line and transient disturbances; an electrode force current recording oscillograph is also available which is of particular advantage in setting up and maintaining the dual electrode force welders, particularly those using the stored energy system of current applications.

Power Supply

All types of resistance welding require an adequate power supply. The power supply situation should be studied as one of the first problems when planning a welder installation.

A line voltage variation of more than plus or minus 5% may have an adverse effect on weld quality. Welders should be placed near the power transformer, not on the end of a long line.

A system of power supply which has given good results consists of bringing into the welding section the highest voltage available in the distribution system and stepping it down to the welder voltage with a suitable indoor type transformer. This prevents long runs of relatively low voltage cable, reduces line drop to a minimum, and gives lower copper cost.

Miscellaneous

Cleaning is highly important. Careful attention must be given to the cleaning of material in preparation for welding to remove scale, oxide, grease and all other types of foreign material from the parts to be welded. If cleaning is not done, faulty welding and excessive electrode maintenance can be expected. A study of the formula of I^2RT, mentioned early in this article, will explain why the "R" (Resistance) on improperly cleaned material will be erratic, giving poor electrical contact between the work and the electrode surface, causing burned work. There are several satisfactory methods of cleaning, such as grinding, pickling, wire brushing or sharp steel grit blasting. When cleaning materials such as stainless steel, magnesium and aluminum, the cleaning must be done within a few hours before the welding is done or the metals will reoxidize and require recleaning.

When blasting is used for cleaning, sand should not be used as it will stick into the surface of the material and give partial insulation, causing considerable trouble. Round steel shot also should not be used as it will often break up scale on the surface of the material and drive the particles back in on edge. Whatever method of cleaning is used, a thorough job must be done.

Safety

Safety precautions must be used while operating welding machines. Operators must wear goggles or face shields to protect the eyes. Jigs and fixtures should be so designed that the operators' fingers will not be caught between the electrodes when feeding small parts. The safety precautions are

similar to those used on punch presses.

When materials which give off toxic fumes are being welded, adequate forced ventilation should be used.

Inspection

A welded assembly will be no better than its component parts. The parts should be carefully inspected to see that they conform to the drawings, are properly formed, true to dimension, and are of the called for material.

The complete structure should again be inspected to see that the dimensions conform to the drawings; that the welding is properly done; that it conforms to the strength requirements; is suitable from an appearance standpoint; and, that no sloppy procedure has been used.

When welding under code requirements, the inspector should see that the code is adhered to.

The welding inspector has an important job and should be well trained and have authority to inforce the quality requirements.

The use of one of the statistical methods of quality control is to be encouraged for the control of weld quality.

Supervision and Operation

While skilled operators are not always required to operate a welding machine, carefully trained set-up men and supervisors are a must if a resistance welding fabrication section is to deliver the maximum production of a quality product with a minimum of rejected parts and assemblies.

They should be thoroughly familiar with all types of welding machines, controls, and the instruments used for their adjustment and maintenance, electrodes and electrode materials, and of the various materials being welded.

Conclusion

The use of resistance welding is to be encouraged where high-speed low cost production is desired.

It can be used to weld practically all of the known metallic materials in like or dissimilar combinations, and the quality and consistency of the product will be on a par with the equipment that is used and with the personnel operating it.

Attention should be given to production costs rather than first cost of equipment.

In the past, too much welding has been done by guess rather than know how. At present there is no excuse for operating a welding section by guess as information is available from many reliable sources, such as the American Welding Society, Resistance Welder Manufacturer's Association, Welding Research Council, and the individual manufacturers of machines, welder controls, instruments, and auxiliary equipment. Advantage should be taken of these sources of information.

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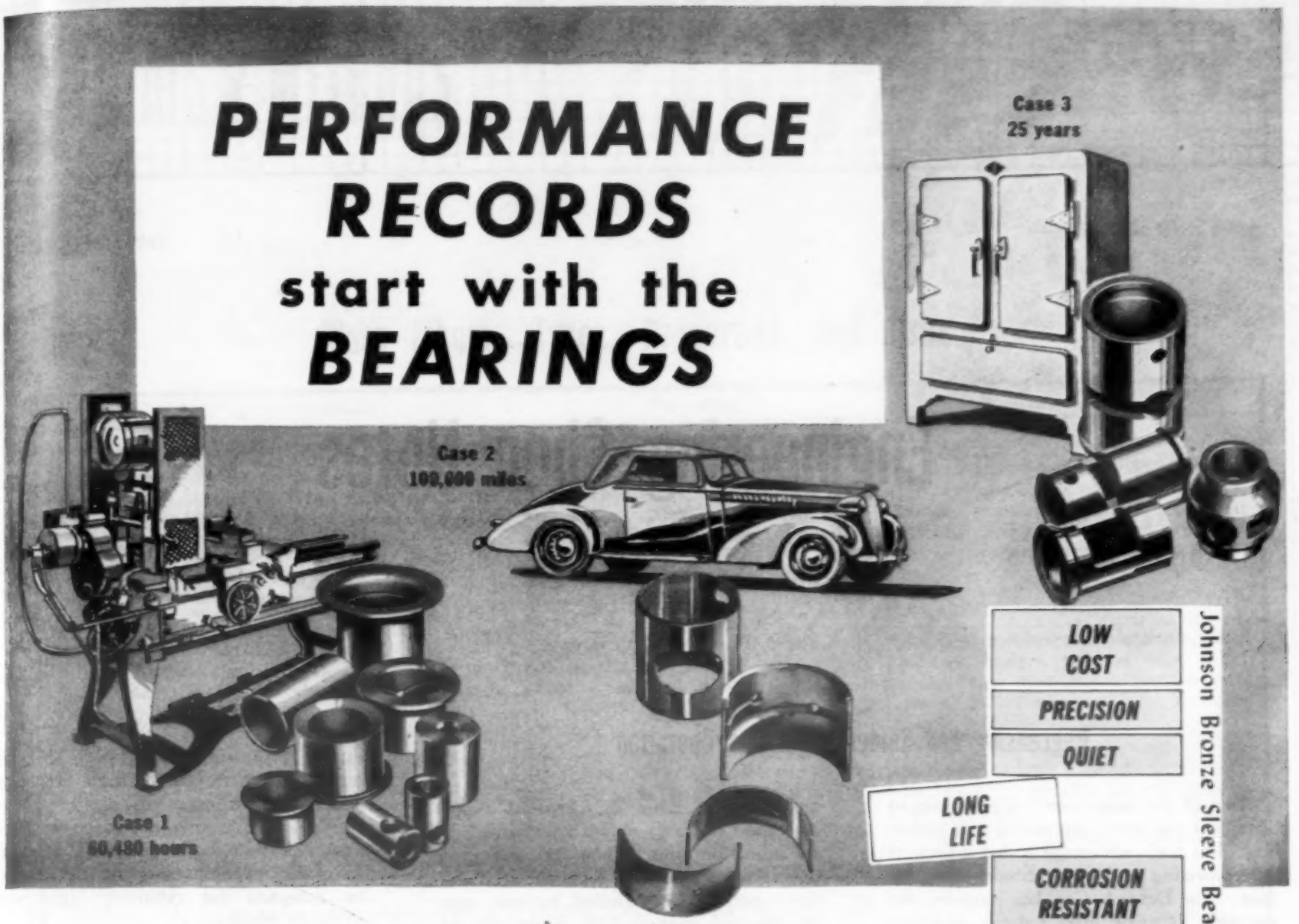

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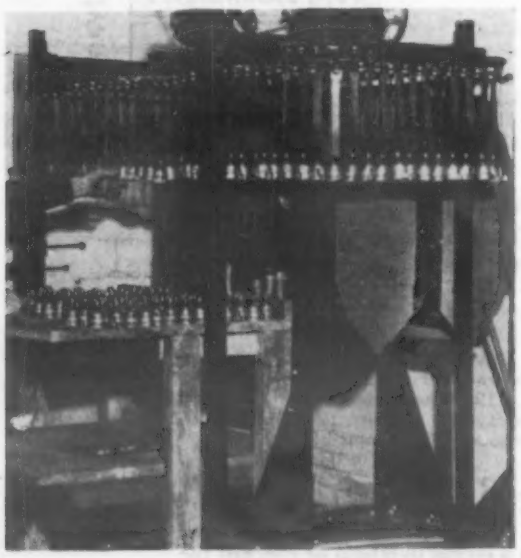
Engineering Shop Notes

Degreasing and Soldering in One Operation

Two of the most recent applications of infra red are metal degreasing and soldering. The main advantage is that it permits conveyorizing and thus reduces handling cost. The Deutsch Co., Los Angeles, for example, is using infra red for soldering adapters to brass refrigerator valves and has increased output from 180 to 200 units per hr., using less operators.

The Barcolo Manufacturing Co., Buffalo, was the first known user of infra red for degreasing metal products. In this process there is no flame present; the grease is charred and goes up in smoke. At Barcolo, chair frames are degreased in 2½ min.

At the Fostoria Pressed Steel Corp., Fostoria, Ohio, soldering and degreasing are performed on a variety of parts for lighting equipment in one operation. The parts are passed through a duo-purpose oven on a conveyor. Previously the degreasing was done by chemical vapors and the soldering was accomplished by an induction unit. Then, at least three people were required. Now the combination operation is handled by one man. By the old method 120 pieces per hr. were soldered, not including assembly or degreasing. Now the parts are soldered, degreased and assembled at the rate of 480 pieces per hr.



These parts are degreased and soldered in one operation by means of infra red radiation.

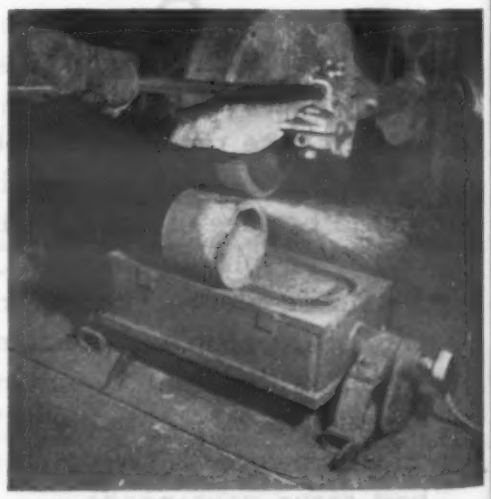
That old bugaboo, distortion, is frequently met in welding problems, so here are a few suggestions as to means of minimizing such distortion. If the surface to be built up is not already worn so, it should be ground smooth. Preheating to unlock stresses may be helpful, if permissible. Electrode size should be small, and the current kept in the mid-range for that size to prevent excessive local heating. Beads should be kept thin and should be well peened. Only small areas should be covered between peenings. Alternate layers should be laid at right angles. Plenty of elbow grease on the wire brush between welds will help yield sound metal build-up. Adjacent beads should overlap about 40% of bead width.

—Courtesy "Welding Arcs," published by the General Electric Co.

Magnets Solve Clamping Problems

There are many jobs in the shop and foundry where magnets are a handy and efficient means of holding parts in position during processing operations. They can often eliminate cumbersome clamping and jigging arrangements.

With the recently developed magnetic materials that have increased magnetic strength, ingenious holding devices can be designed for relatively light jobs.



Shown here is an electromagnet holding a casting in position under a swing grinder.

Where heavier holding requirements must be met, electromagnets will often do a satisfactory job.

Recently an electromagnet designed for holding heavy castings in position under a swing grinder was developed by Dings Magnetic Separator Co. The magnet will hold a variety of cast shapes, thereby eliminating need for blocking, wedging or clamping. The wearing plate on which the castings are placed is removable so that it can be replaced when worn out. In this particular design the electromagnet is mounted on a tilting trunnion with seven positions controlled by foot lever. The magnet can be turned on and off by means of a hand or foot switch.

NUMBER 151
November, 1947

Glass Fibers—Types, Properties, and Uses

Type	Forms	Properties	Typical Uses
WOOL—fine fibers, nominal average diameter 55 to 85/100,000 in.; for insulating purposes, thermal or acoustical.			
White Wools (Unbonded)	Bulk or shredded. Batts, thickness ¾-3 in. Rolls, similar to batts, but available in longer lengths.	Densities ½, 1, 1½ or 2 lb. per cu. ft. low moisture absorption, low thermal and acoustical conductivity, varying with density; when installed at 3 lb. per cu. ft. density, k (thermal conductivity) = 27 B.t.u. at 70 F. For temperature ranges from subzero to 1000 F.	General purpose thermal insulation—for domestic heated equipment, trucks, busses, ships, aircraft hot air ducts; also for refrigerated spaces. Acoustical applications, especially aboard aircraft.
Bonded Wools, Thermosetting Resin Binder	Flexible, medium, semi-rigid, rigid, board. Flexible and medium blocks 1-4 in. thick; semi-rigid 1-3 in.; rigid 1-2 in.; and board ¾-2 in.	Densities 2.5, 3.25, 4.25, 6 and 9 lb. per cu. ft., respectively. For 2.5-lb. grade, k = .29 B.t.u. at 70 F; for 6-lb., .26, and for 9-lb., .25 B.t.u. For use to 450 F.	For heat insulation in domestic water heaters, boilers, railroad cars, ships, tanks, etc.; also for acoustical purposes. Board used as filler in composite building partitions.
Asphalt Coated	Board, 1-3 in. in thickness.	For 6-lb. density, k = .265 B.t.u. at 60 F; for blocks of 9 lb. per cu. ft., k = .26 B.t.u. at 60 F. Not subject to rotting.	For low temperature applications—refrigerator rooms, cold storage lockers. Denser grade suitable for self-supporting partitions.
Enclosed Wools, Bonded and Unbonded	Paper-faced and paper-enclosed batts and blankets, unbonded fibers.	—	Especially for building insulation.
	Canvas or roofing felt jacketing, resin-bonded fibers, preformed wire mesh faced blanketing, unbonded fibers.	Bonded fibers for temperatures to 600 F, unbonded fibers to 1000 F.	For pipe insulation.
	Cloth-faced sewn blankets, unbonded fibers.	—	For sound stacks, etc.
	Metal mesh faced blankets, bonded or unbonded fibers.	—	For boilers, process equipment, breeching, etc.
TEXTILES—coarse or medium fibers spun and formed into fabric; the most versatile form; largely electrical insulations or in plastics laminates.			
Yarns	Continuous filament. Staple fiber (about 9 in. avg. length).	Strong, noncombustible, excellent electrical characteristics.	Electrical insulation—serving over fine wires, etc.
Braided Sleeving, Cordage, Woven Tapes, Cloth	Continuous filament or staple fiber in braided or woven form.	Higher strength than most other textiles; remains stable and maintains electrical properties under moisture changes.	Sleevings for motor lead wires, binding for coils, other electrical insulation uses; as pipe lagging, filter medium for acidic or weakly alkaline solutions; facing material for insulating blankets or boards; laminating material for plastics; decorative or fireproof textile.
Coated Cloths	Neoprene, vinyl resins, etc., applied to woven fabrics.	Resistant to oils, most acids, moisture and heat. High tensile strength, good resistance to flexing and abrasion.	Aircraft engine gaskets, protective clothing for workers in chemical plants, conveyor belts, etc.
Combination Textiles	Glass fiber — cotton fabrics. Glass fiber—asbestos fabrics.	Better abrasion resistance and flexural strength.	For domestic applications; heavy industrial fabrics.
PACKS—coarse, medium or fine fibers; 800 to about 450/100,000 in. dia.; for air filtration			
Air Filters	1- and 2-in. thicknesses faced with metal grilles.	Inert material, not affected by moisture.	A filter for heating or air conditioning installations.
Contact Packs	½-in. thickness.	—	For humidifying or dehumidifying in air conditioning.
Tower Packing	Large surface area.	Low weight, inert to most acids.	For process industries.
MATS—fine and superfine fibers			
Battery Retainer Mats	For use in storage batteries.		—
Underground Pipe Wrap	Protective wrapping for buried pipe.		—
Industrial Mat	Impregnated with binder and compacted.	Strong, inert, good heat resistance, good electrical properties.	For gaskets, sheet packing, surfacing on acoustical panels, etc.

Compiled by Kenneth Rose, Engineering Editor

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For example, the manufacturer of this chair arm, with alternative material, would have paid for at least five separate finishing operations, plus cost of materials and inspection of each step.

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MATERIALS & METHODS **Engineering File Facts**

NUMBER 152
November, 1947

MATERIALS: Abrasives

Properties of Hard Abrasives

Properties of the most important of the hard abrasives have been tabulated in the publication Werkstattstechnik/Werkleiter, *Vol. 36, 1942, and revised and extended in* Industrial Diamond Review, *Apr., 1947. A condensation of this interesting table is given below.*

Abrasive	Structure		Physical Properties						Application
	Chemical Composition	Purity	Color	Surface	Mohs' Scratch Hardness	Toughness	Specific Gravity	Melting Point, C	
Glass	Silicate melting sodium or potash combined with lime and silica	—	White	Smooth	4-6	Brittle	2.4-2.9	500-600 (930-1110 F)	As glass paper for wood and fibrous materials
Pumice	Solidification product of volcanic fused mass	Frequently rendered impure by feldspar hornblende	Grey to white	Rough	5-6	Friable	0.91	—	Fine grinding of wood, leather, fibrous material, soft plastics, smoothing
Cerium Oxide	CeO_2,Ce_2O_3	Mostly pure	White	Uneven	6	—	6.9-7.3	1950 (3540)	For polishing glass
Kieselguhr	65-87% SiO_2, 23-11% Al_2O_3, and Fe_2O_3	Rendered impure by feldspar hornblende	Browny, grey-white	—	7	Friable	2.2	—	Iron, glass and stones
Tripoli	Decomposition product of flint	95% silicic acid	White	—	7	Friable	2.2	—	For gem stones
Quartz	SiO_2	Mostly pure, contains iron	White, yellowish	Uneven	7	Tougher than glass	2.65	1500-1600 (2730-2910)	Grinding glass (as sandstone), steel, malleable steel, (knives, files, a.s.o.)
Flint, Agate, Chalcedony	SiO_2	—	Brown, grey	Uneven	7	Tough	2.6	—	For abrasive paper, wood and leather.
Garnet	$Ca_2Al_2Si_3O_{12}$ /Mg_3/Fe_2 Mn_2Cr_2	Mostly pure	Deep red to pink	Smooth to uneven	7	Brittle	3.4-4.3	1315 (2400)	Abrasive papers, soft and hard wood, leathers
Emery I	$Al_2O_3+Fe_2O_3$ and others	60-65% Al_2O_3	Grey to brown	Uneven	8-9	Tough	3.7-4.3	2200 (3990)	Many workshop purposes; malleable steel, cast iron; good for polishing
Emery II	$Al_2O_3+Fe_2O_3$ and others	40-60% Al_2O_3	Dark brown	Rough	8	Tough	3.7-4.3	—	Inferior workshop purposes; malleable steel, mill stones
Corundum (Natural)	$Al_2O_3+Fe_2O_3$ SiO_2,H_2O	90-98% Al_2O_3	Pale yellow to white	Smooth to uneven	9	Parting	3.7-4.3	2050 to 2350 (3720-4260)	Especially malleable steel and other kinds that clog up grinding wheels
Technical Corundum I	$Al_2O_3+Fe_2O_3$ $+SiO_2+TiO_2$	90-99% Al_2O_3	Reddish to white	Uneven	9	Brittle to tough	3.9-4		Hardened, mild and malleable steel (especially heavy grinding); cast steel
Technical Corundum II	Al_2O_3 and others	70-90% (to 98%) Al_2O_3	Grey to brown to black	Uneven to rough	8-9	Tough to friable	3.9-4.3		Composite abrasive for heavy grinding, millstones, etc.
Silicon Carbide	SiC	Mostly very pure	Black-green to bottle green	Smooth stepped	9-9.5	Brittle	3.15-3.2	2700 (4900)	Cast iron, hard rubber, all brittle materials, plastics, brass, aluminum, copper, etc.
Beryllium Oxide	BeO	—	White	—	9	—	3.025	2332[1] 4440[2]	Grinding of sintered carbide
Boron	B	—	Black	Smooth	9-10	Brittle	2.3	2300 (4170)	—
Boron Carbide	B_4C	97% B_4C	Grey	—	9-10	Brittle	2.52	2350 (4260)	Hard metal tools and dies, abrasive paper and cloth
Diamond	C	Mostly very pure	White, pale yellow to black	Smooth to uneven	10	Brittle	3.5	3700 ± 100 (6700 ± 200)	Diamond dust as abrasive for sintered carbides, sapphires, diamonds. Rough and shaped tools

[1] *B. Kleinschmidt, Schleifen i.d. Metallbearbeitung, Vol. 1, p. 19.*

[2] *Lange's Handbook of Chemistry, 5th edit., p. 167.*

MATERIALS & METHODS

DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Special High Strength Cast Irons

Condensed from "Fonderie"

An investigation was made of 12 cast irons to find a composition that would give high mechanical properties. The irons, which were melted in a basic arc furnace, included two unalloyed irons, a nickel-chromium (2 nickel-0.2% chromium) iron and nine nickel-molybdenum (1.4 nickel-0.6% molybdenum) irons. The latter irons were divided into three main groups, with about 2.35, 2.6 and 2.8% carbon, and with varying silicon content in each group.

Tensile strengths of at least 56,900 psi. and particularly high impact values were obtained with the nickel-molybdenum irons containing 2.7 to 2.9% carbon and over 1.7% silicon. The carbon may be lowered to 2.6% if the silicon is increased to about 2.3%. Although the best mechanical properties were obtained with the nickel-molybdenum irons containing less than 2.7% carbon and 1 to 2.3% silicon, the higher strength of these lower carbon and lower silicon irons was offset by their greater susceptibility to porosity. The following composition was selected as optimum since it combines high strength with an absence of porosity: 2.7 to 2.9 carbon; 1.7 to 1.9 silicon; 0.6 to 0.8 manganese; 1.5 to 1.7 nickel; 0.5 to 0.6% molybdenum.

A supplemental investigation was made to determine the most favorable conditions for inoculation with calcium. The amount of calcium silicide added was sufficient to increase the silicon content of the iron by about 0.2 to 0.25%. Additions were made in the furnace and at the spout; only the latter proved really efficient. Inoculation had a definitely beneficial effect on all the mechanical properties in spite of the higher silicon content of the inoculated iron.

No positive conclusions could be drawn as to the effect of casting temperature except that porosity was more marked in the samples cast at lower temperatures. (G. Delbart & R. Potaszkin. *Fonderie* (French), No. 18, June 1947, pp. 673-682.)

Applications of a New Metals Comparator

Condensed from a Paper of the Instrument Society of America

The metals comparator furnishes a convenient and nondestructive rapid method of determining whether or not a particular piece of metal is identical with a standard specimen in composition and characteristics. This is done by inserting the piece in the center of a solenoid forming one leg of a balanced circuit, the other leg of which is a variable resistance. Balance is first obtained with a standard specimen inside the solenoid. If the piece tested is identical, a balance will again be obtained. If it is not identical with the standard specimen, the impedence of the test coil is not the same and the circuit is unbalanced, a condition which can be read on a microammeter.

The instrument has been used to differentiate between annealed and unannealed steel bars. It has also been used to sort finished metal parts, including plated parts, on the basis of average hardness. Material or parts to be tested need not be wiped, cleaned or otherwise specially prepared for testing.

Specimens can be tested as rapidly as they can be inserted in the test coil and removed after allowing the instrument pointer to come to rest. Tolerances can be established so a specimen is accepted or rejected on the basis of whether the pointer reading is within a specified number of scale divisions from the center.

Among the practical problems that have been solved successfully by the metals comparator is that of identification of steel bars in storage. A number of 1-in. dia. cold drawn steel bars (AISI C1020) in a stock room were thoroughly mixed after each had been stamped with an identifying number. Part of them had been non-scale annealed and the rest had not. All of the unannealed bars produced readings in the range of plus three to minus two, while all of the annealed bars of the same material produced readings in the range of plus eight to plus thirteen.

Where a mixed lot of bars is known to consist of only two or three different types, it is a simple job to select a few of each type and try testing at several different frequencies and sensitivities to see which gives the best results. If the mixture contains more than two or three different types, a few of each type should be tested at each of several different frequencies and the data thus secured plotted in the form of curves.

Some tests have been conducted in connection with the determination of plating thickness. It was found that there was identification between thick and thin plating of the same metallic material on both magnetic and nonmagnetic base materials, and that there was relationship between the thickness of nickel plating on brass and the comparator reading.

Data have been secured that indicate that the comparator can be used to sort steel parts on the basis of their Rockwell hardnesses. The principal difficulty encountered in correlating hardness with magnetic properties is that of determining the actual hardness of the standard samples with which unknown parts can be compared. For example, several hex nuts submitted by an automotive manufacturer were tested on a standard Rockwell Tester, and the variations in hardness as measured at two points on each of the six faces of a single nut ranged from a Rockwell C reading of 27 to 34. With such conditions the comparator will indicate only whether the average hardness of the nut being tested is more or less than the average hardness of the standard nut with which it is compared. (D. E. Bovey. Paper, *Instrument Soc. of Am.*, 9 pp.)

Semiconducting Ceramic Materials

Condensed from "Journal of the American Ceramic Society"

It is difficult to draw distinct boundaries between conductors, semiconductors, and insulators. Semiconductors might be said to have specific resistances at room tempera-

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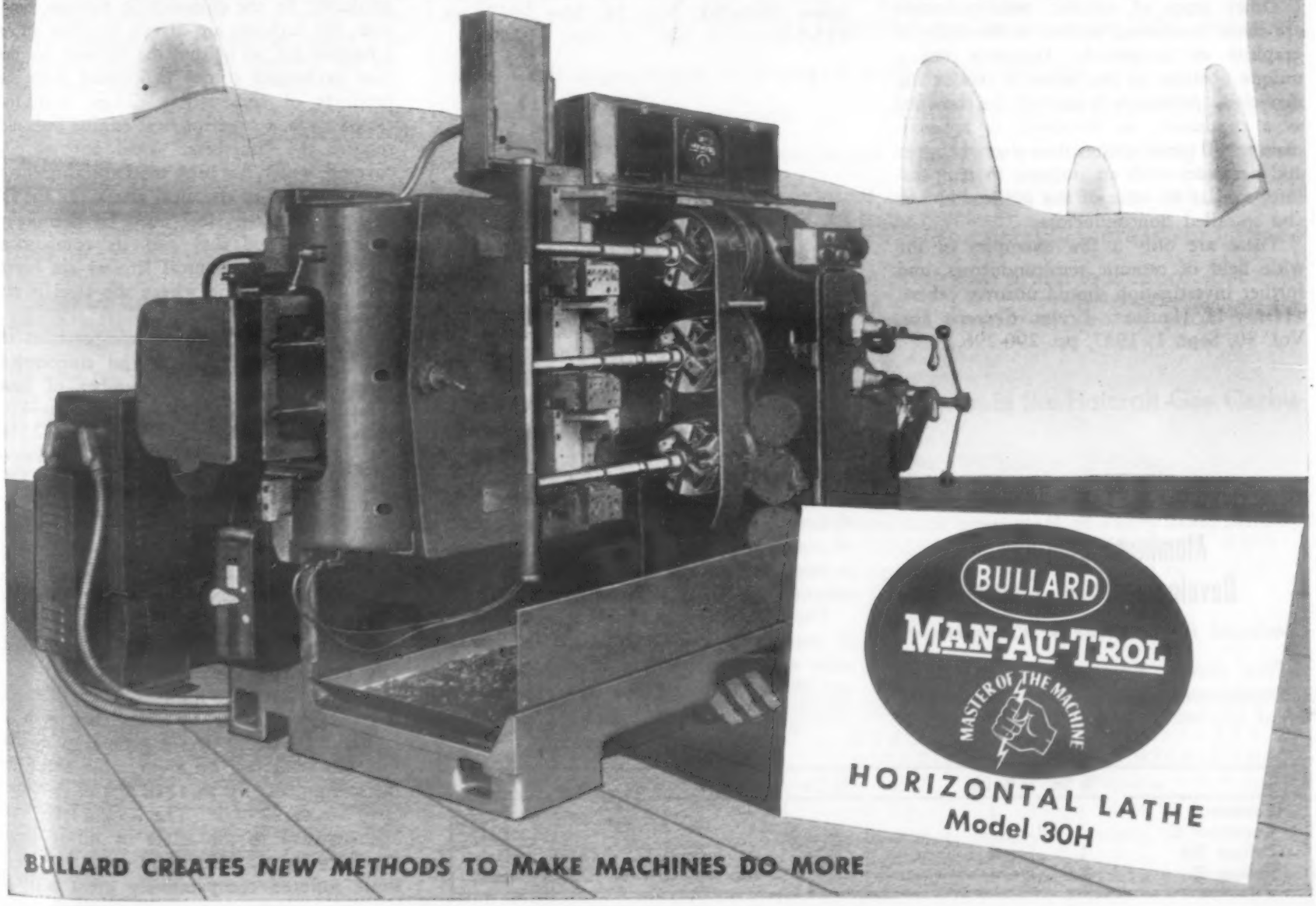

BULLARD CREATES *NEW METHODS* TO MAKE MACHINES DO MORE

DIGEST

tures from 0.1 to 10^9 ohm-cm. Semiconductors also usually have a high negative temperature coefficient of resistance.

One method by which semiconductors can be produced is mixing conducting materials with insulating materials and forming a compact of this mixture.

Another type of semiconductor is the oxide in which the conduction is a function of its oxygen content or of the degree of oxidation. Experiments were conducted to determine the effect of small additions of nonmagnetic metal powder to mixtures of zirconium dioxide and iron oxide. The experiments showed that the temperature coefficient of ceramic semiconductors can be easily changed, even without essential change in resistivity, by transforming one oxide into another and by adding some other oxides.

Titanium dioxide in the form of rutile is known as a dielectric material of high quality. Partial reduction of TiO_2 changes this insulation material into a semiconductor, and the degree of conduction depends on that of reduction. By adding nickel powder to this material the resistivity increases when nitrogen is fired but is lowered when refired in hydrogen.

Other types of ceramic semiconductors are those containing carbon in the form of graphite or lampblack. Graphite has a unique position in the series of conducting materials. Although it can still be classified as a conductor, its resistivity is approximately 500 times greater than that of copper and decreases with an increase in temperature, similar to most of the semiconductors and so-called nonconductors.

These are only a few examples of the wide field of ceramic semiconductors, and further investigation should uncover others. (Henry H. Hausner. *J. Am. Ceramic Soc.* Vol. 30, Sept. 1, 1947, pp. 290-296.)

Aluminum Bearings Developments in France

Condensed from "Revue de l'Aluminium"

Four French aluminum bearing alloys are considered in detail. Their compositions are as follows:

	% Sn	% Pb	% Sb	% Cu	% Mg	% Mn	% Zn	% Al
Coussinal A	3	2	3	—	—	—	—	Bal
Coussinal C	4	—	—	4	3	1	—	Bal
Palium DA	1	4	—	4	0.8	0.3	22	Bal
Palium Z	2.6	4	—	4.5	0.6	0.3	0.3	Bal

The excellent bearing properties of these alloys are indicated not only by laboratory tests but also by satisfactory performance in service. Mention is made of the preliminary results of various uncompleted tests on binary and ternary alloys of aluminum with nickel, manganese, antimony, molybdenum, cobalt, iron, magnesium and chromium.

In general, aluminum bearing alloys may be cast, forged, rolled or drawn so the bearings may be fabricated as needed for best service. The mechanical properties of these alloys are such that they can support high loads while retaining their good friction properties. As a result of the good thermal conductivity, aluminum bearing alloys perform satisfactorily at high operating temperatures. Their machinability makes it possible to obtain perfect surface finishes. They are not attacked by the lubricants normally used nor by the modern detergent lubricants.

Furthermore, their great ability to absorb oil gives a factor of safety in case there is an accidental stoppage of lubrication. The low specific gravity is of particular advantage in aircraft motors. The clearance is more important with aluminum than with other bearing metals because of the high coefficient of expansion of the former. Although the Americans claim these bearings can be used with semi-hard steels, they are preferably used in contact with a hard steel or, better yet, carburized or nitrided steel.

In conclusion, the aluminum alloys may be applied under severe service conditions where the white metals and cadmium alloys and even lead-copper alloys are no longer suitable. (M. Goret. *Rev. Aluminium* (French), Vol. 24, May 1947, pp. 155-169.)

Fracture of Metals

Condensed from a Paper of the American Society for Testing Materials

According to a prevalent view, plastic deformation has practically no effect on the fracture stress (technical cohesion limit) of any metals except pearlitic steels and metals with similar microstructure; also, the effect of plastic deformation on the fracture stress of pearlitic steels is anisotropic. These views are questioned by the authors and their experiments were designed to determine whether the effect of plastic deformation on the fracture stress is merely anisotropic or is a work-hardening effect similar to the effect on the flow stress.

The first series of experiments consisted of tension tests of longitudinal and transverse specimens from hot-rolled steel plate and from plate that had been extended cold by tension. The second series consisted of tension tests of specimens cut from cylindrical bars that had been compressed various amounts. Tension tests were made at room temperature and in liquid air.

From the results it was concluded that the general effect of plastic deformation on the fracture stress is a work-hardening effect similar to the effect on the flow stress; also that any kind of plastic deformation of any polycrystalline metal affects the fracture stress in the same way that it affects the corresponding flow stress.

The results of these tests confirm conclusions expressed in previous papers by the authors that the influence of plastic extension on the flow stress and fracture stress can be represented by two curves rising and intersecting at a small angle. The ductility thus is sensitive to the differential effect of any variable on the flow stress and fracture stress. (D. J. McAdam, Jr., G. W. Geil & W. H. Jenkins. Paper, *Am. Soc. Testing Materials*, 19 pp.)

Scaling of High-Strength Heat-Resisting Steels

Condensed from "Journal of the Iron & Steel Institute"

In the gas turbine, as in any heat engine, the hot structural components are exposed not only to mechanical stresses but also to the chemical attack of the combustion products. In the closed-cycle turbine, however, the turbines are driven by clean air or a neutral gas, so neither the turbine nor the heat exchanger comes in contact with the products of combustion. Thus, with the closed cycle, a superior heat engine does not require the "universal" steel not yet discovered, which has high mechanical strength and resistance to chemical attack. In the air heater where the steel must be chemically resistant to the fuel and its combustion products, the mechanical stresses are lower than in the turbine where the steel is exposed to clean air only.

Various scaling tests at temperatures of 1110 to 1830 F in air and combustion gases were made on a number of heat resisting steels: 18% chromium—8% nickel; 18% chromium—8% nickel—2.5% silicon; 25% chromium—20% nickel—1.5% molybdenum; 16% manganese—15% chromium; 14% chromium—1% nickel; 17% chromium—1% nickel; 27% chromium—4.5% nickel—1.5% molybdenum; 18% manganese—9% chromium—0.5% titanium; and 18% manganese—12% chromium—0.5% vanadium. The tests were continued for 120 hr. but were interrupted four times by intermediate cooling.

In some cases, the high sulfur combustion gas caused less scaling than that with a low sulfur content. As a general rule, the sulfur content had no appreciable effect on the scaling loss up to 1110 F and in some cases up to 1290 F. The 25-20 type was less sensitive to the effect of sulfur than the 18:8 type. The 16-15 and the 14-1 steels suffered comparatively great scaling

DIGEST

losses even in air. Contrary to opinions expressed previously, the 17-1 and the 27-4.5-1.5 types were not superior to the chromium-nickel steels.

It is not justfiable to transfer the results immediately to practice since scaling usually does not increase linearly but becomes slower with increasing exposure times. (W. Stauffer & H. Kleiber. *J. Iron & Steel Inst.* (British), Vol. 156, June 1947, pp. 181-188.)

Influence of Boron on Properties of Steel

Condensed from "Journal of Research"

It is now recognized that the hardenability of some types of steel is materially improved by the addition of small amounts of boron. Tests were made to determine the influence of varying amounts of boron additions made with different intensifiers (ferroalloys containing boron), on the cleanliness, structure, austenite, and McQuaid-Ehn grain sizes, hardenability, notch toughness at room and low temperatures and tensile properties at room temperature of experimental and commercial steels. The study was extended with some of the experimental steels to include the effect of variation in deoxidation practice on the above properties; the effect of boron on temperatures of transformations when slowly heated and cooled (Ac and Ar) and when rapidly cooled (Ar"); the effect of boron on weldability; and the recovery of boron on induction melting and remelting under normal and oxidizing conditions.

Below are listed a number of conclusions derived from the investigation:

Variations from nil to 0.006% of boron additions made with either simple or complex intensifiers had no significant influence on the following properties of the steels: (1) Cleanliness, except titanium or zirconium inclusions in some steels treated with complex intensifiers (nonmetallic inclusions), (2) hot working (experimental steels), (3) transformation temperatures (Ac_1, Ac_3, Ar_3, Ar_1 and Ar", experimental steels), (4) resistance to softening by tempering, (5) weldability (experimental steels), and (6) tensile of fully hardened and tempered specimens, except possibly an improvement in ductility when tempered at low temperatures.

Boron lowers the coarsening temperature of austenite. However, steels with relatively high additions of boron can be rendered fine grained at heat-treating temperatures by the judicious use of grain-growth inhibitors such as aluminum, titanium, and zirconium.

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Further details on the process are given in the Holcroft Gas Carburizing bulletin, available on request.

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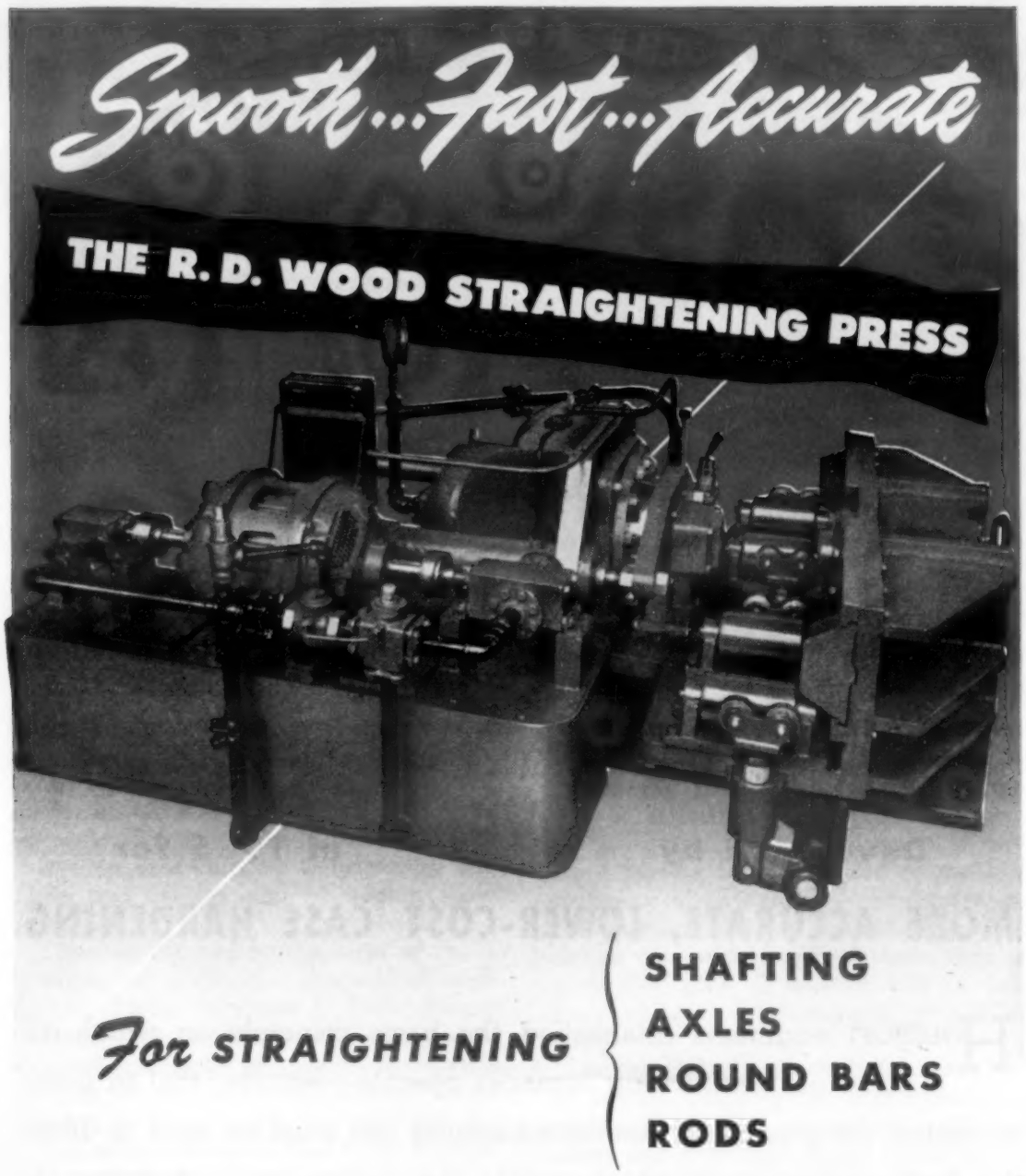

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DIGEST

The influence of boron on hardenability and on notch toughness (Charpy impact, V-notched specimens) of fully hardened and tempered steels varied with the base composition of the steels, the composition of the intensifiers, and the amount of boron present.

The increase in hardenability due to boron was greater for basic open-hearth than for experimental steels prepared in an induction furnace. The notch toughness at room and low temperatures of the commercial steels fully hardened and tempered at high temperatures was also superior to that of the experimental steels of similar composition heat treated alike.

The hardenability, as determined by the end-quench test, of many of the experimental and all the steels comprising a basic open-hearth heat were markedly improved by additions of boron. However, no definite correlation was found between the hardenability effect and the amounts of boron added or retained in the steels.

For the commercial steels, the magnitude of the hardenability effect was independent of the amount of boron added or retained and the composition of the intensifiers.

The magnitude of the hardenability effect due to boron appears to depend upon the form in which it exists in austenite; not necessarily upon the total amount present.

The addition of small amounts of boron was often beneficial to the notch toughness at room temperature of the steels when fully hardened and tempered at low temperatures.

When the steels were fully hardened and tempered at high temperatures the presence of boron, especially as relatively high additions with intensifiers containing titanium, was usually either without effect or was detrimental to notch toughness at room and subzero temperatures.

The notch toughness of many of the steels fully hardened and tempered at 1000 F was not affected appreciably by a change in test temperature from room to —95 F. (Thomas G. Digges & Fred M. Reinhart. *J. Research*, Vol. 39, July, 1947, pp. 67-131.)

The Fatigue Strength of Some Tin-Base Alloys

Condensed from "Metallurgia"

Since fatigue strength is one of the most important properties of white metals for bearings, the fatigue strength at 212 F (a reasonable average operating temperature) was determined for a series of tin-base alloys.

DIGEST

The fatigue strength of tin-antimony-copper alloys (with up to 14 antimony and 7% copper) increases in general with increasing antimony and copper contents. The effect of solid solution antimony and eutectic copper is much greater than that of either element in the form of massive compounds. Beyond a certain point, the addition of further compound phase has an erratic effect on the fatigue strength. The only effect of fatigue testing on microstructure is to cause the precipitation of fine particles of antimony-tin in alloys with over 7% antimony. The precipitation in the worked surface of polished specimens kept at room temperature is much greater. Changes in casting conditions within a reasonable range do not significantly affect the fatigue strength.

There is evidence of a fatigue strength maximum at about 7 antimony and 1% copper, which corresponds approximately to a ternary peritectic complex. Alloys of tin with lead, cadmium and zinc having similar structures as well as ternary peritectic alloys of tin-antimony-silver and tin-antimony-cadmium were investigated. Except for the tin-lead alloys, all the eutectic-like alloys have about the same fatigue strength. Additions of antimony over 0.5%, which result in the formation of primary zinc-antimony, do not increase the fatigue strength.

The fatigue strength of certain tin-base alloys is increased by 1% bismuth or 0.1% tellurium. The addition of tellurium may be worth consideration in the case of the commercially important 7 antimony-3.5% copper alloy, which occupies a minimum point on the fatigue strength curve for 7% antimony; as the tellurium increases its fatigue strength up to that of the 7 antimony-1% copper alloy. (P. G. Forrester, L. T. Greenfield & R. Duckett. *Metallurgia* (British), Vol. 36, July 1947, pp. 113-117.)

Continuous Casting of Nonferrous Metals in Germany

Condensed from "Metal Industry"

In Germany alone, some 50 firms are continuous casting nonferrous metals. The amount of light metals so cast exceeds by far the amount being cast in ordinary molds. Developments with other nonferrous metals may be expected to proceed in the same direction.

The first continuous casting machine for brass (Wieland-Werke-Junghans) has been in use since 1933 without any breakdowns and without any fundamental modification. This machine first incorporated the essential

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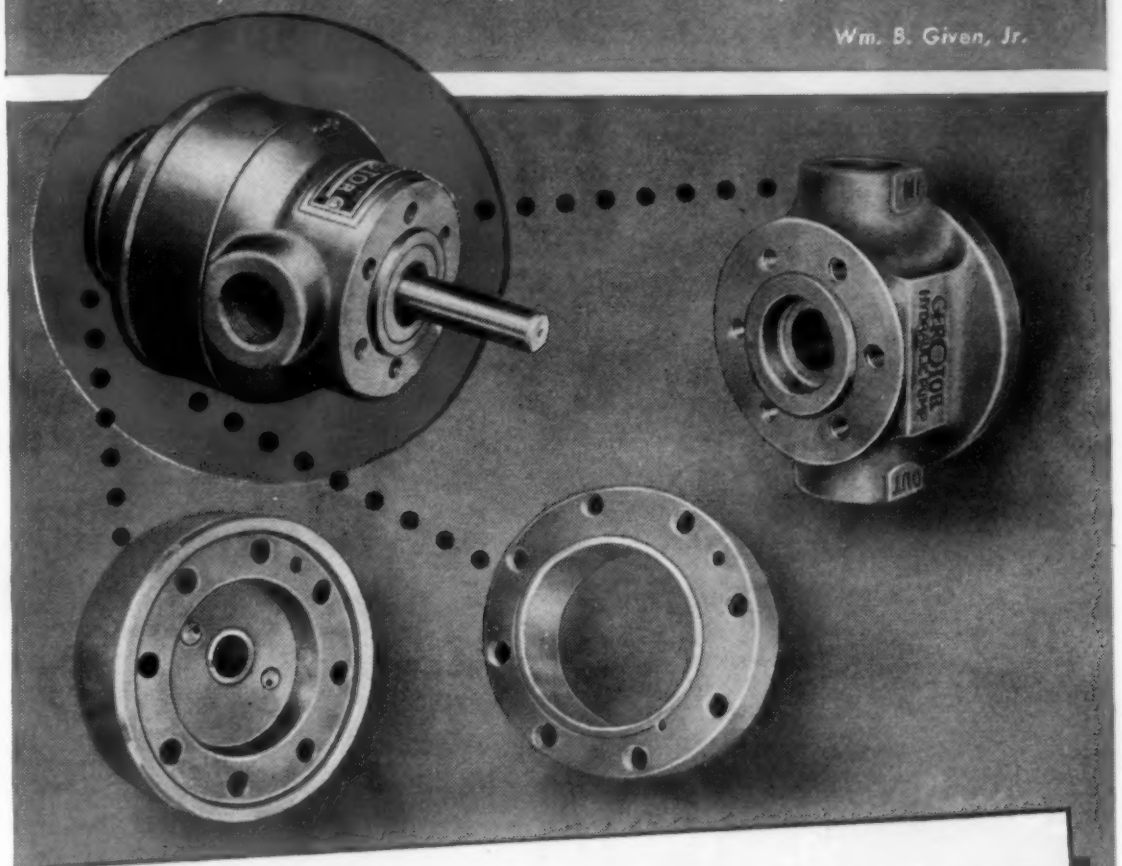

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DIGEST

characteristics for any successful continuous casting—namely, the maintenance of constant temperature, feed and speed. Other machines of this type were later put into operation casting bronze, zinc, aluminum and magnesium. In 1936 Vereinigte Leichtmetall-Werke developed independently a continuous casting process for light alloys which is being used in a number of light metal plants both in Germany and abroad.

Both processes use a water cooled bottomless mold to which metal is supplied at a constant rate and temperature. In both cases, the solidified billet is lowered at a speed which ensures that the level of molten metal in the mold remains constant. The differences are the way the metal is fed to the mold, the way its rate of flow is controlled and the fact that Wieland-Werke-Junghans decided upon a fully continuous process whereas Vereinigte Leichtmetall-Werke preferred a semi-continuous process. These are minor differences, but there are certain essential metallurgical differences, mainly connected with the method of removing the heat and its effect on segregation.

In view of the short mold in the Vereinigte Leichtmetall-Werke machine and the direct water cooling of the billet immediately after it leaves the mold, the loss of heat downwards is very considerable. Consequently, inverse segregation is reduced to a minimum. The attendant disadvantage of the drastic cooling is the formation of high shrinkage stresses which necessitate modifications when alloys sensitive to internal stresses are cast.

A high output even with a low pouring rate can be achieved with both processes by casting a number of billets simultaneously. Various suitable control and distributing devices have been developed for this purpose. With metals which should be cast without exposure to air, closed feed pipes terminating below the level of the molten metal in the mold are advantageous. To avoid eddying and erosion, it is advisable to use a distributor vessel placed just above or below the level of the molten metal in the mold.

It is impossible to give a generally applicable answer to the question of whether the fully continuous or the semi-continuous process is to be preferred. In general, the former is more suitable where a large output of billets of the same size and alloy is required, whereas the latter is better suited for a more varied output. Experiments in which the continuously cast billet is rolled in a mill placed directly after the casting machine have given good results since 1939 and are to be continued.

The continuous casting of hollow sections, especially by the fully continuous process, presents a number of advantages.

DIGEST

Labor in piercing solid billets is saved and the waste of metal in machining is all but eliminated. Moreover, hollow billets can be cast much more rapidly than solid billets of the same outside diameter in the case of alloys liable to crack as a result of internal stresses. (H. Kastner. *Metal Ind.* (British), Vol. 71, Aug. 1, 1947, pp. 83-85; Aug. 8, pp. 106-108; Aug. 15, pp. 131-132; as abstracted from *Stahl u. Eisen*, Vol. 66/67, Jan. 2, 1947, pp. 10-19.)

The Frictional Properties of Some Lubricated Bearing Metals

Condensed from "Journal of the Institute of Metals"

Under full fluid lubrication, the material of the bearing surfaces plays no part in determining friction and suffers no surface damage. Almost all bearings, however, must operate for limited periods within the region of mixed friction. Under these conditions, the fluid film-forming capacity of the material will determine the area subject to boundary friction and hence influence the amount of surface damage, the frictional losses incurred, and the amount of heat involved.

A comparison was made of the frictional properties of four common bearing alloys as regards boundary friction and fluid film-forming capacity: (1) tin base (7 antimony, 3.25% copper, balance tin); (2) lead base (13 antimony, 0.25 copper, 12% tin, balance lead); (3) copper lead (30% lead, balance copper); (4) cadmium nickel (1.4% nickel, balance cadmium). Their kinetic friction against lubricated steel was examined at low sliding velocities.

In general, the coefficient of friction of all four alloys was increased by decrease of sliding velocity, by increase in surface roughness of the steel, and by increase in temperature. The effects of these factors were not independent. A considerable proportion, at least, of the influence of these factors was due to their influence on the transition from boundary to fluid friction which in some circumstances can commence at velocities below 0.2 in. per sec. even with high specific loading.

There were no important differences among the four alloys in regard to boundary friction, as represented by the friction at very low velocities. Considerable differences did exist, however, in respect to the capacity for aiding or maintaining fluid lubrication. This property will determine the conditions under which boundary friction first occurs

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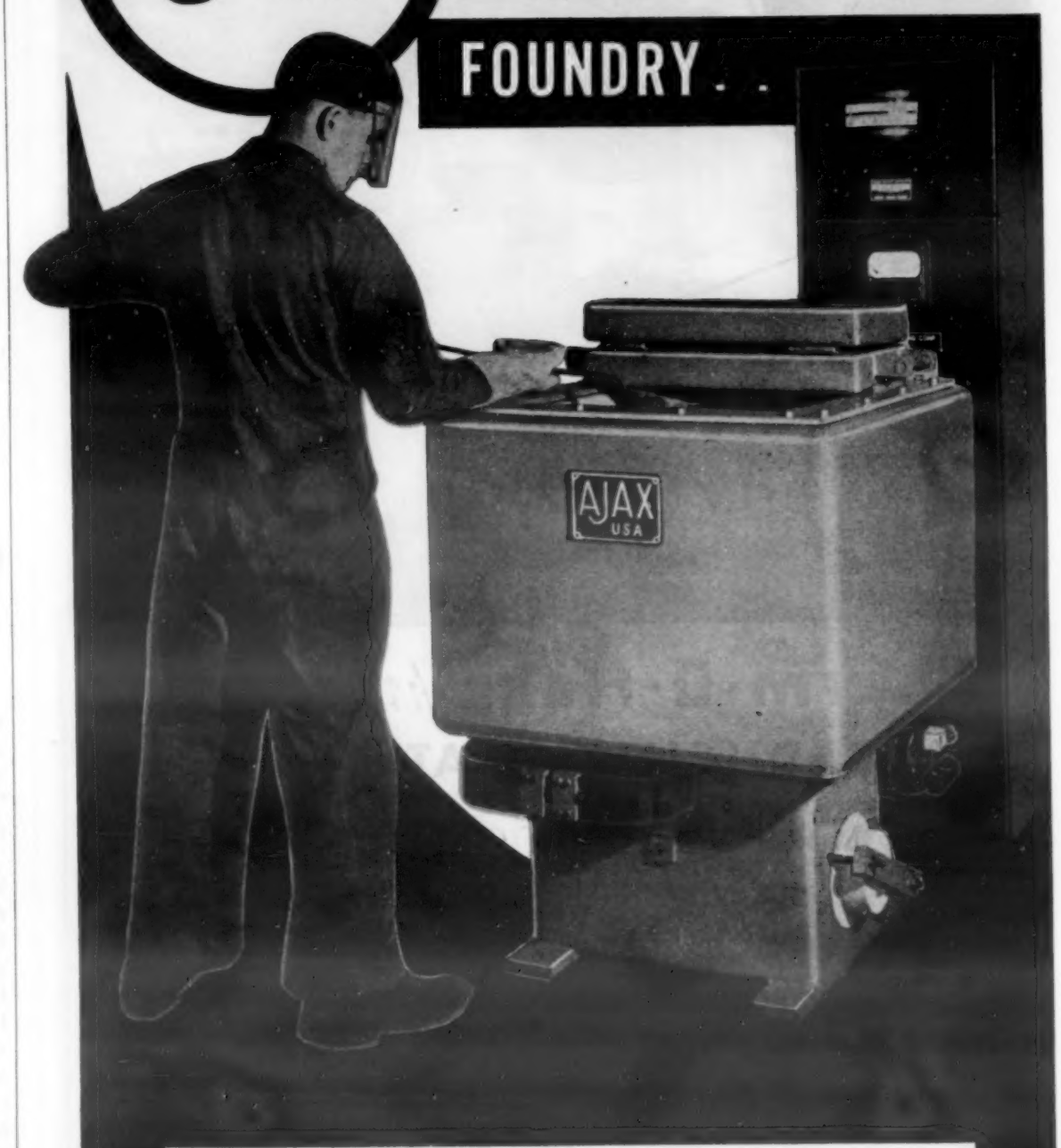

THE AJAX-Tama-Wyatt Low Frequency Induction Furnaces are now made in small sizes with capacities ranging from 20 to 35 kw.

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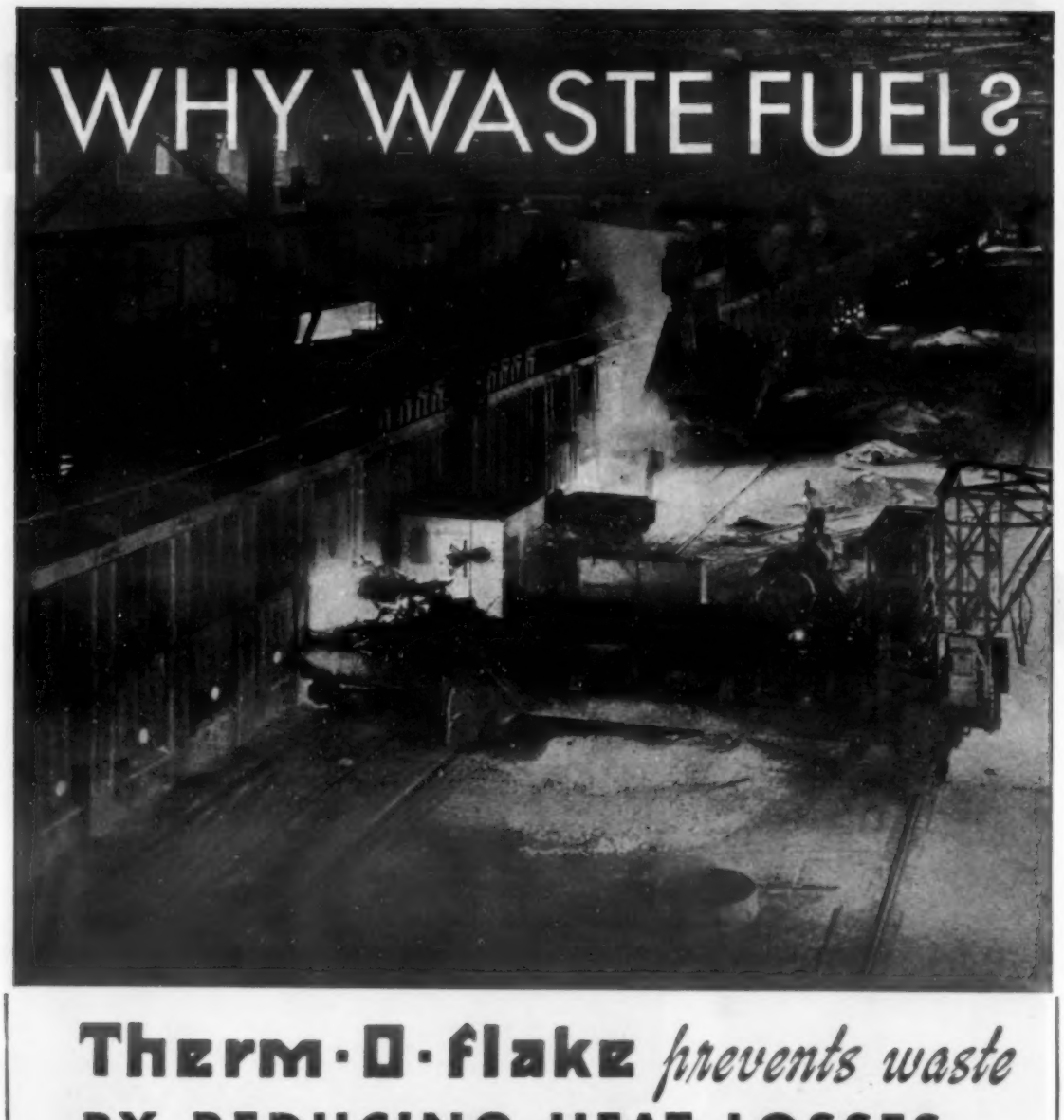

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DIGEST

in a given design of bearing. The tin and lead base Babbitts promoted fluid friction to a much greater extent than the copper lead alloy, while cadmium nickel had in general intermediate properties. These differences are likely to have a considerable influence on the behavior of a bearing whenever there is some degree of boundary friction. (P. G. Forrester, *J. Inst. Metals* (British), Vol. 73, Part 10, 1946/7, pp. 573-589.)

A New Method for the Determination of Silica Inclusions in Steel

Condensed from "Revue de Métallurgie"

The previous methods for the determination of silica inclusions in steel require either a complicated procedure or a high temperature in addition to strong reagents. The present method is simpler and much more rapid.

The annealed steel, which is the anode, is dissolved electrolytically while the nonmetallic inclusions are not attacked. A high conductivity electrolyte containing 10 gm. sodium chloride, 100 gm. potassium bromide and 30 gm. sodium citrate per liter is used. The anode is surrounded by a glass cylinder with the bottom closed by silk cloth to retain the nonmetallic inclusions. The use of a diaphragm is avoided by the adoption of a mercury cathode. These measures reduce the total electrical resistivity of the equipment to less than half an ohm, so the electrolysis requires under 10 v. with a current of 20 to 25 amp.

The temperature of the solution near the anode increases rapidly during operation to about 120 to 140 F. The electrolyte becomes slightly alkaline during electrolysis so it is gradually replaced by fresh solution. Sufficient steel for an analytical determination of the silica (about 20 gm.) is dissolved in 45 min. The residue is washed with hot and cold water, a hot solution of 3% sodium carbonate, and a 1% hydrochloric acid solution.

The silica in the residue is then determined chemically. Alumina can also be determined if desired. The reproducibility is good and the results check closely with those obtained in the bromine method. The time for the entire operation depends somewhat on the carbon content of the steel, but is about 3 hr. (A. Skapski, A. Bielanski & M. Sobieski. *Rev. Métallurgie* (French), Vol. 43, July-Aug. 1946, pp. 229-233.)

Materials and Their Processing

METALS AND PLASTICS—PRODUCTION AND PROCESSING. *By Thomas P. Hughes. Published by Irwin-Farnham Publishing Co., Chicago, 1947. Cloth, 6¼ x 9¼ in., 373 pages. Price $4.50.* This is a textbook on materials used in manufactured products, with emphasis on metallurgy and metalworking and treating processes. It was written to present a comprehensive perspective of manufacturing processes with a detailed study of some of the more common metals, alloys, and plastics so that the student will have an understanding of their fundamental potentialities and a basis for selection to help him develop the ability to appraise the advantages and limitations of materials and of production processes.

Titles of the chapters are: Metals and Their Internal Structures; Equilibrium Diagrams; Physical Properties of Metals; The Manufacture of Iron; Casting Processes; Ferrous Castings; Manufacture of Wrought Steels; Nonferrous Metals and Alloys; Iron-Iron Carbide Diagram; The Heat Treatment of Steels; The Mechanical Working of Metals; Welding Processes, Equipment and Applications; Brazing and Brazing Alloys; Plastics Materials, Processes and Uses; and Classifications of Steels.

Welding Encyclopedia

THE WELDING ENCYCLOPEDIA — TWELFTH EDITION. *Revised and re-edited by T. B. Jefferson. Published by Welding Engineer Publishing Co., New York, 1947. Simulated leather, 6 x 9 in., 1024 pages. Price $6.50.* This volume is composed of five sections: Part I is an encyclopedia of welding; Part II is an appendix presenting tables and charts dealing with specifications, examples of good and bad welds, temperature conversion tables and an electrode comparison chart which lists various welding electrodes by trade names and comparable AWS designations; Part III is a dictionary of trade names; Part IV is a buyers' manual; and Part V is the index.

It was necessary to replace 300 pages of material of the previous edition to take care of the advances that have been made in welding during the war. Many of the alterations and additions were suggested by readers. Information regarding metallurgy, metals, underwater welding, underwater cutting, weld inspection methods and

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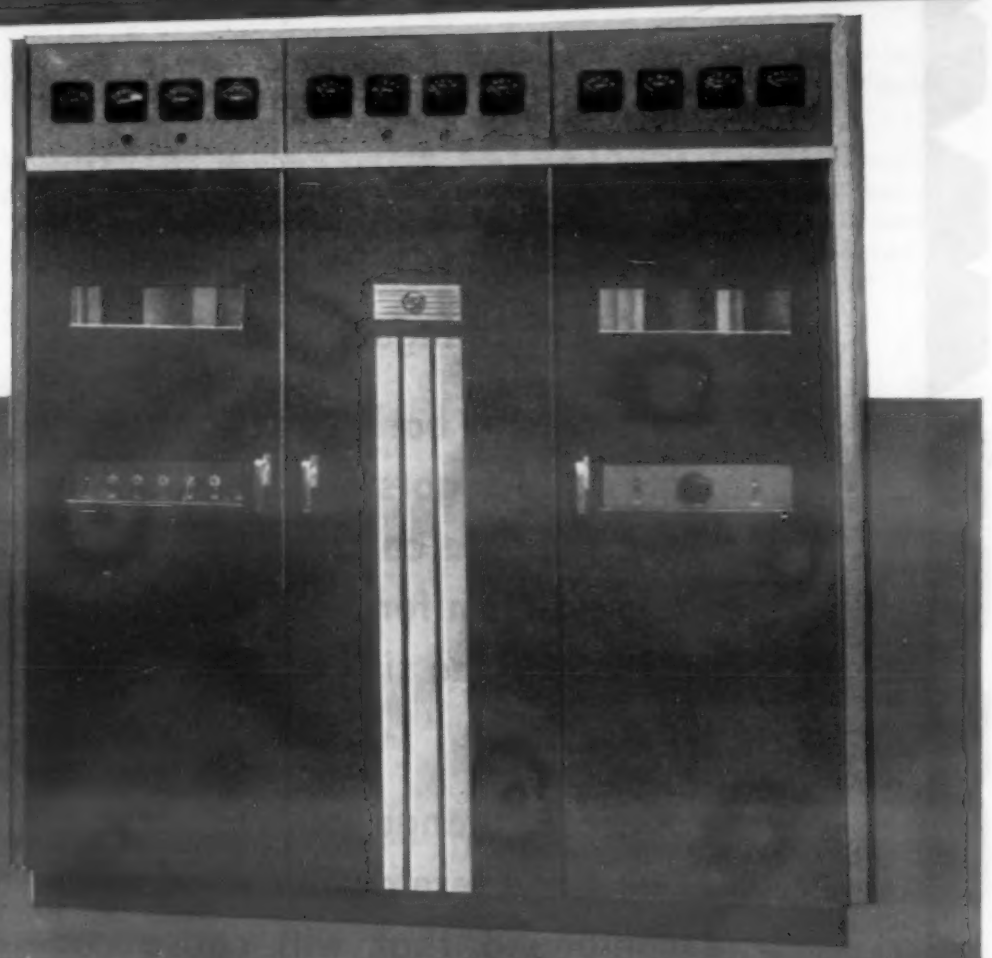

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data on the various welding processes has been greatly expanded.

Data on structural welding together with the latest welding codes, boiler welding and boiler welding codes as well as information on welding symbols and welding in general as applied to design, construction, production and maintenance are also included.

Metallurgy Text

AN INTRODUCTION TO METALLURGY — SECOND EDITION. *By Joseph Newton. Published by John Wiley & Sons, Inc., New York, 1947. Cloth, 6¼ x 9¼ in., 645 pages. Price $5.50.* This is intended to present an introduction to the field of metallurgy and to provide a foundation for advanced and special studies in metallurgical subjects. Principles rather than practice are emphasized, and generalized discussions are used as far as practicable.

A large part of the text has been rewritten, but the general arrangement and content of the first edition has not been changed except for the omission of the sections on pyrometry and calorimetry.

Important features include an expanded discussion of pyrometallurgy, new material on corrosion, more alloy diagrams, and the addition of a section on powder metallurgy.

Other New Books

BIBLIOGRAPHY OF THE PLATINUM METALS—1918-1930. *By James L. Howe et al. Published by Baker & Co., Inc., Newark 5, N. J., 1947. Cloth, 7¾ x 11¼ in., 138 pages. Price $5.00.* Brings up to the end of 1930 the Howe Bibliography of the Platinum Metals 1748-1917.

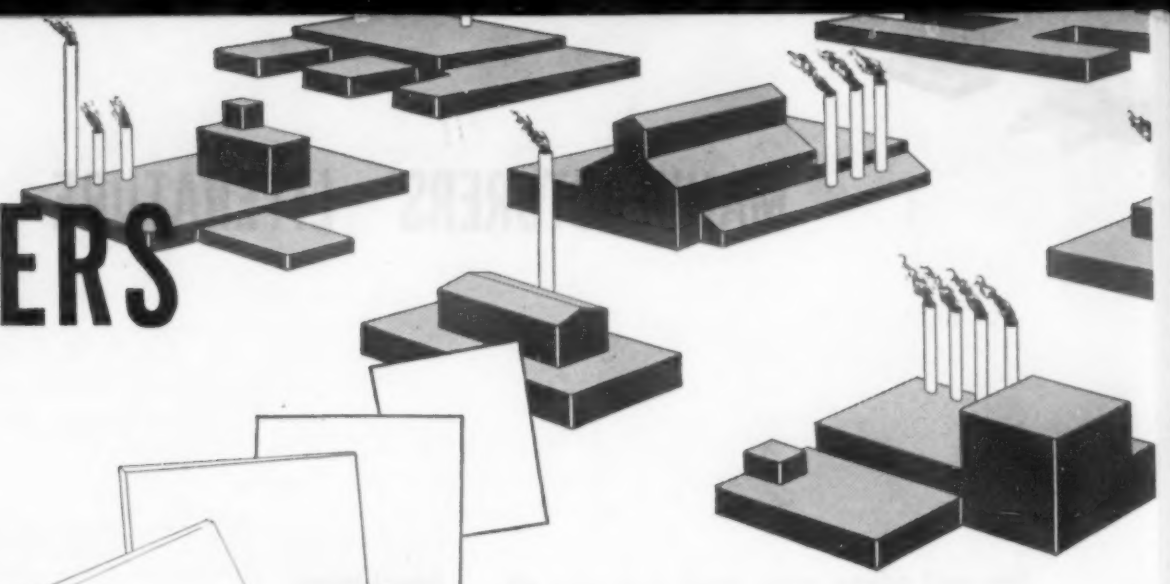
REPORT ON STANDARD SAMPLES FOR SPECTROCHEMICAL ANALYSIS—1947. *Published by American Society for Testing Materials, Philadelphia 3, Pa. Heavy paper, 6 x 9 in., 23 pages. Price $1.25.* Chiefly a list of available standard samples including iron and steel; aluminum and its alloys; magnesium and its alloys; zinc, lead and tin alloys; copper alloys; etc.

FOUNDRY MANUAL—MELTING AND MOLDING OF FERROUS AND NONFERROUS METALS AND ALLOYS. *Published by U. S. Navy Bureau of Ships; for sale by Supt. of Documents, U. S. Government Printing Office, Washington, D. C. Paper, 7¾ x 10¾ in., 157 pages. Price 55c.* Methods now in use at the various Navy Yards, at the Naval Research Laboratory and by industrial foundries for the production of steel, cast iron, bronze, brass and aluminum alloy castings are described. The phases of foundry work covered are design, pattern making, sands, core making, molding, pouring, heat treatment and cleaning.

HANDBOOK OF INDUSTRIAL ELECTROPLATING. *By E. A. Ollard & E. B. Smith. Published by Louis Cassier Co., Ltd. (Distributed by Iliffe & Sons, Ltd.), London, England, 1947. Cloth, 5¾ x 8¾ in., 308 pages. Price 15/.* A collection of data on electroplating, including the installing and maintaining of electrodeposition plants.

HARD SURFACING BY FUSION WELDING. *By Howard S. Avery. Published by the American Brake Shoe Co., New York, 1947. Cardboard, 7¾ x 9⅝ in., 100 pages. Illustrated.* This is the first of a series of Monographs on Wear to be prepared for engineers and practical men, which will condense a large volume of specialized data into concise form. Economics, materials engineering and methods of hard surfacing are covered.

MANUFACTURERS LITERATURE



Materials

Iron and Steel

High-Speed and Tool Steels. A handy list of high-speed and tool steel warehouse stocks which indicates types, shapes and sizes available and shows exact location of each item in stock is offered by the Tool Steel Div. of the Allegheny Ludlum Steel Corp. in a 62-page catalog. (1)

Wrought Iron. This 20-page, illustrated booklet discusses in detail what wrought iron is, why it resists corrosion and withstands shock and vibration, how it is made, bent, welded and threaded, as well as typical applications. A. M. Byers Co. (2)

Molybdenum High-Speed Steels. Detailed information on the composition, application, cutting properties, forging, protective coatings, annealing and heat treatment of molybdenum high-speed steels is available in a 30-page booklet published by the Climax Molybdenum Co. (3)

Cast Nickel Alloy. The engineering properties and applications of Ni-Resist, a group of corrosion and heat resistant nickel-copper-chromium cast irons, are presented in this 36-page, illustrated catalog, just revised by the International Nickel Co., Inc. (4)

Heat Treating Steel Castings. The effect of homogenization temperature and time in the heat treatment of steel castings is discussed in a 4-page bulletin, No. 9, published by the Steel Founder's Society of America. (5)

Nonferrous Metals

Aluminum Casting Alloys. Tabular data on physical and mechanical properties of various sand and permanent mold aluminum alloys, general metallurgy of aluminum alloys, properties of specific alloys, foundry practice, and heat treatment are all included in a 78-page, illustrated, loose-leaf binder, published by the Aluminum Research Institute. (6)

Pre-Finished Metals. Complete data and practical fabricating suggestions relative to the proper handling of pre-finished Nickeloid Metals are presented in an attractive, 16-page, illustrated bulletin offered by the American Nickeloid Co. Charts on properties, sizes, weights, gages and conversion factors are included. (7)

Beryllium Copper. Detailed information on the physical properties, recommended heat treatments, forming characteristics, test specifications and thickness tolerances of Berylco 25S, a 2% high-strength beryllium copper available in strip, wire and rod, are presented in this 4-page data sheet, No. 2, published by the Beryllium Corp. (8)

Die Casting Alloys. This handy, pocket-size folder contains seven separate data sheets covering aluminum-base, magnesium-base, zinc-base and copper-base alloys, and their finishes, for a variety of die castings produced by the Doehler-Jarvis Corp. (9)

Corrosion and Electrical Heat Resistant Alloys. A complete data on Nichrome, Chromax, Advance and a number of other high nickel electrical heat and corrosion resisting alloys produced by the Driver-Harris Co. are presented in a 72-page catalog, No. R-46. Numerous tables, charts, specifications, and prices are included. (10)

Parts and Forms

Corrosive Resistant Process Equipment. Thirty-six products made of Durco corrosion resisting alloys, produced by the Duriron Co., Inc., are listed in an 8-page, illustrated bulletin, No. J, offered by the Duriron Co., Inc. Specifications are included. (11)

Stainless and Alloy Steel Valves. A variety of stainless and alloy steel valves that provide advanced operating characteristics for corrosive, high temperature and high pressure service requirements are discussed in a 4-page, illustrated bulletin, No. 47-AS, offered by the Kerotest Mfg. Co. Specifications are included. (12)

Magnesium Castings. Complete data on the machining and finishing of magnesium castings are presented by the Superior Magnesium Castings Div. of the Superior Bearing Bronze Co., Inc. in an 8-page bulletin. Numerous diagrams and tables are included. (13)

Small Metal Tubing. Factual information on both seamless and Weldrawn fine small tubing (0.010- to 0.625-in. A. D. max.) in many metals is contained in a 4-page illustrated bulletin, No. 31, offered by the Superior Tube Co. (14)

Aluminum Alloy Tubes, Pipes, Etc. A complete line of extruded and rolled Whitelight aluminum tubes, pipes, conduits, bars, strips, etc., and the various alloys used in these products, are described in a 4-page bulletin issued by the White Metal Rolling & Stamping Corp. (15)

Plastics

Phenolic Resins. Various phenolic resins now available and their uses for making compounded rubber stocks and solvent-type adhesives are discussed in a 4-page, illustrated bulletin published by the Durez Plastics & Chemicals, Inc. (16)

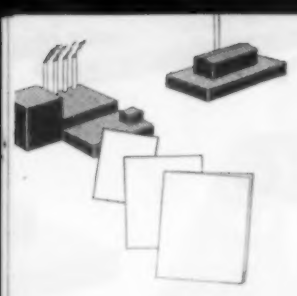
Plastic Molding. The facilities, equipment and production capacity of Kurz-Kasch, Inc. for the custom molding of plastics by compression and transfer are described and illustrated in a 16-page folder. (17)

Thermoplastic. Physical properties and typical applications of Tenite, a thermoplastic molding material made from Eastman cellulose esters, are included in an attractive, 32-page, illustrated bulletin, fifth edition, just published by the Tennessee Eastman Corp. (18)

Methods and Equipment

Heat Treating

Stainless Annealing Furnace. A variety of furnaces for the bright annealing of stain-



MANUFACTURERS' LITERATURE

less steel tubing, wire, sheet, strip, etc., are described and illustrated in a 4-page bulletin, No. B-4, issued by the Drever Co. (19)

Induction Heating. The Smith-Dolan low frequency induction heating system used in preheating and normalizing operations for welding and other industrial heating applications is discussed in a 20-page, illustrated bulletin issued by Electric Arc, Inc. (20)

Induction Heating Machine. The many advantages of using the new Trigatron induction heating machine to harden, braze, solder, heat treat, anneal and melt are listed in a 4-page, illustrated bulletin issued by Gordon Electronics, Inc. Specifications are included. (21)

Welding and Joining

Bolts, Nuts, Screws, Rivets, Etc. Several interesting articles on the selection of the proper fastener, and the correct design of fastened parts are presented in this 20-page, illustrated publication, No. 2, of the American Institute of Bolt, Nut & Rivet Manufacturers. A complete list of terminology and abbreviations is included. (22)

Arc Welders. A variety of electric powered, multi-range, dual control arc welders that offer 1000 combinations of current and open circuit voltage for the job at hand, are described and illustrated in a 4-page bulletin, No. 8974, issued by the Hobart Brothers Co. (23)

Acid-Proof Cements. Basolit, a quick-setting acid-proof and insulator cement manufactured in three grades—standard, carbon and Plasul—Nukemite, a synthetic resin coating, Nu-Mastic, an asphalt cement, Sealtex, a rubberized plastic, and several other types are all described in a 12-page illustrated bulletin published by Nukem Products Corp. (24)

Forging and Forming

Continuous Extrusion Takeup. A new type combination capstan and continuous takeup for the continuous extrusion takeup of synthetic or rubber coated wires, cords or cables is described and illustrated in a 12-page bulletin offered by Industrial Ovens, Inc. Specifications are included. (25)

Hole Punching Units. A complete line of Wales Type "CD" hole punching units for punching mild sheet metal up to ⅛-in. thick is described and illustrated in the third edition of a 16-page catalog, No. CD, offered by the Wales-Strippit Corp. Specifications are included. (26)

Machining

Cutting-Off Machine. The Aminco wet bonded abrasive-wheel cutting-off machine for cutting metals, plastics, glass, etc., in the form of sheets, rods, tubes or blocks is featured in a 6-page illustrated folder, No. 2154, released by the American Instrument Co. Specifications and prices are included. (27)

Cutting Oil. Typical applications of Lusol, a liquid concentrate that assures cooler, higher speed production with grinding, machining, sawing, milling and threading tools, are described in a 12-page, illustrated booklet, No. AL-2, issued by the Anderson Oil Co. (28)

Raised Hub Disk Wheels. The many advantages of using Bayflex raised hub disk wheels for the grinding and polishing of any type of welded or brazed metal are featured in a 4-page, illustrated bulletin issued by the Bay State Abrasive Products Co. Prices are included. (29)

Automatic Milling Machines. Complete specifications and applications of two types of plain automatic milling machines, Nos. 1-12 and 1-18, are included in this profusely illustrated, 24-page bulletin, No. M-1555, offered by the Cincinnati Milling Machine Co. (30)

Grinding Wheels. Complete data on the use of single-ribbed and multi-ribbed wheels in thread grinding operations as well as the new method of centerless screw thread grinding are presented in a 36-page, illustrated booklet offered by the Norton Co. Specifications are included. (31)

Cleaning and Finishing

Phosphate Coating. Two grades of phosphate coating, Thermoil-Granodine Nos. 101 and 102, for producing a dense crystalline coating on most types of iron and steel, and on chilled and cyanided ferrous surfaces, are discussed in a 2-page Technical Service Data Sheet, No. 7-11-101-5, issued by the American Chemical Paint Co. (32)

Metal Cleaning. The many advantages of using the Airless Wheelabrator for metal cleaning operations in the gray iron foundry are discussed and various types of the Wheelabrator illustrated in a 20-page bulletin offered by the American Wheelabrator & Equipment Corp. (33)

Washers. Two types of Detrex washers, using either Triad alkali cleaning compounds or petroleum spirits and emulsion cleaners, are featured in this 24-page, illustrated bulletin published by Detrex Corp. (34)

Zinc Plating. Detailed operating instructions for Zin-O-Lyte, a bright zinc plating process for yielding very bright, low cost, rust resistant deposits, are presented by the Electroplating Div. of E. I. du Pont de Nemours & Co., Inc. in an 8-page bulletin, No. A-4455. (35)

Selenium Rectifiers. Typical applications of a variety of selenium electroplating rectifiers for d.c. plating power are featured in this 20-page, illustrated bulletin released by the Federal Telephone & Radio Corp. Specifications and 22 recommended plating layouts are included. (36)

Electroplating Conveyors. A variety of full automatic plating conveyors—the elevator type, Munning type and straight line type—for electroplating, wire and cable plating, and zipper plating are described in a 22-page, illustrated bulletin, No. FA-103, offered by the Hanson-Van Winkle-Munning Co. (37)

18:8 Stainless Steel Paste. The application of the corrosion resistant properties of 18:8 stainless steel in the form of paint to any surface where superior resistance to corrosive conditions is required is announced in a 2-page bulletin released by Charles Hardy, Inc. Prices are included. (38)

Synthetic Organic Detergents. Typical applications of a complete line of synthetic organic detergents and wetting agents produced by the Miranol Chemical Co., Inc., are suggested in this 32-page catalog. (39)

Pre-Cleaning Aluminum Surfaces. A variety of cleaning compounds for the pre-cleaning of aluminum surfaces prior to painting, depending upon the aluminum alloy used and the finish required, are listed in a 4-page field service special report published by Oakite Products, Inc. (40)

Rust-Inhibitive Coating. The advantages of an application of Rockcote zinc chromate, a rust-inhibitive coating, on all structural steel as well as aluminum and aluminum alloy building materials, are contained in a 4-page, illustrated bulletin just published by the Rockford Paint Mfg. Co. (41)

Inspection and Control

Infrared Spectrophotometer. Complete data on the Double-beam infrared recording spectrophotometer for measuring and recording the infrared transmission of solids, liquids and gases are presented by Baird Associates, Inc. in an 8-page, illustrated bulletin, No. XXX. Specifications are included. (42)

Fatigue Testing Machine. Bulletin No. 246, four pages, describes and illustrates the Sonntag SF-2 fatigue testing machine, a small, light, motor-driven unit for testing sheet materials in flexure under repeated bending moments, produced by the Baldwin Locomotive Works. Specifications are included. (43)

New Materials and Equipment

Projection Welder for High Production Work

A new high-production projection welder has been announced by the *Federal Machine & Welder Co.*, Warren, Ohio. The first unit has been delivered to a large Eastern typewriter manufacturer where it is in volume operation welding retaining strips and other subassemblies to the steel stampings forming the main typewriter body assembly. Using one semi-skilled operator, the machine produces approximately 200 completed assemblies per hr.

The machine is of welded steel construction. In order to facilitate the loading of pressed steel parts and the unloading of the completely welded main body assembly, which is welded in a single pass through the machine, the mandrel and head are mounted in an angular position. The dies, which have inserts to coincide with the projections on the work pieces, are designed to insure an ample flow of water for proper cooling. Two small air-operated hold-down clamps act as an auxiliary clamping unit and precisely locate the work parts in position during the sequence of welds.

The first projection welder of this type is being used in typewriter production.

Coatings Developed for Maintenance and Production

Synthetic Coating

The development of a new synthetic coating, which can be built up to extra-heavy thicknesses, has been announced by *United Chromium, Inc.*, 54 E. 42nd St., New York 17. Primarily designed to insulate and protect electroplating racks, it has possibilities for numerous other products.

This material contains 100% solids. It is a baking synthetic, applied by dipping or spraying, and cures at 350 F. On some racks, thicknesses up to ¼ in. can be achieved within 2 hr., on areas where such a degree of protection is desirable.

Tests reveal it also withstands a variety of strong chemicals in addition to hot cleaning solutions and all plating baths. Its characteristics make it suitable for use on dipping baskets, wire screens, mixing equipment, propellers, rotors of air-blowers, and as gaskets and linings.

Pattern Lacquer

Development of a new pattern lacquer for use by the foundry industry has been announced by the *Glidden Co.*, Cleveland. The lacquer is used for the preservation and identification of wood patterns and provides a smooth surface to which foundry molding or core sand will not adhere.

The lacquer is said to offer good resistance to water, oil, kerosene, heat and abrasion, and does not become brittle with age or usage. It allows easy and smooth release from hot molding or core sand and reduces patching. It is made in clear, clear orange, yellow, vermillion and black. Luster is medium gloss. It air dries in 15 min. over wood and also over the wax fillets which are used to smooth and fill corners in the patterns.

Alkali-Resistant Enamel

An alkali-resistant enamel for use on industrial machinery has been developed by the *Pittsburgh Plate Glass Co.*, Pittsburgh. The new enamel has a plasticized rubber base vehicle. It is suitable for use on industrial machinery where cutting compounds and oils saponify regular coatings. Typical applications are valve and crankshaft grinders and lathes.

Clear Plastic Coating

A transparent plastic coating for protecting metal surface which is approximately 45% solids is being manufactured by *Calresin Corp.*, Culver City, Calif. These solids belong to the polyester family cross linked with an amino aldehyde resin and plasticizers plus a catalyst to promote drying.

In factory application on metals, the coating may be sprayed or brushed, or the metal may be immersed in the solution. The finish obtained is said to be hard and flexible and prevents corrosion. It is suitable for practically all metals including steel, copper, aluminum and magnesium.

New Attachments and Tools in the Machine Tool Field

Taper Attachment

Master Taper Co., 126 N. Clinton St., Chicago 6. This heavy duty taper attachment for lathes comes in two sizes, 34 and 40 in. between arms and for V or Flat Ways. Can be furnished for all lathes with a 13- to 26-in. swing. Capacity: tapers up to 4 in. per ft., 20° max. in either direction, 16-in. length at one setting. The swivel bar has V-Ways with the ends graduated one end in degrees and the other in inches per foot.

Recessing Tool

Maxwell Co., Bedford, Ohio. A new series of tools for operation on high-speed automatic machines to accomplish grooving, backfacing and recessing. Cutters of tools move in a radial direction in a predetermined ratio ranging from three to eight times more slowly than the forward movement of the spindle so as to maintain the proper cutting feed. Available in four standard sizes for grooving, backfacing and recessing holes ranging from ⅜ to 4 in. in dia.

Carbide Burs

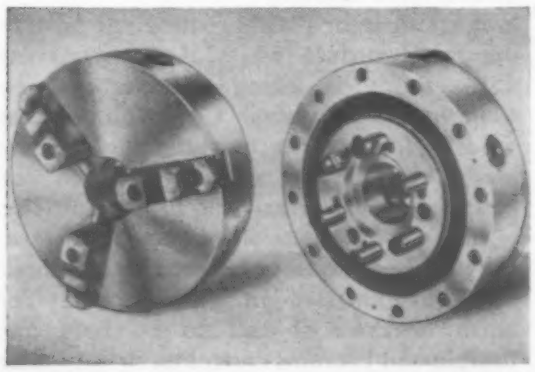
M. A. Ford Manufacturing Co., Inc., 780 W. First St., Davenport, Iowa. This tool was developed for internal grinding, jig grinding, and blending or fine finishing by off-hand grinding. It works equally well on soft materials or on steels hardened to 67 Rockwell C. The burs are stocked in standard sizes from 1/16- to ¾-in. tool dia. for operation in precision grinding equipment at conventional grinding speeds.

Gear Chuck

Garrison Machine Works, Inc., 515-525 Bannock St., Dayton 4, Ohio. This gear chuck was developed for locating bevel gears by the pitch line of the teeth while grinding the bore and a portion of the back face at one chucking. It is draw-bar operated, yet adaptable to different machines, without necessity of providing proper threaded connector, because the operating mechanism is not attached or connected direct to the draw-bar. It can be operated by the machine hand lever, air cylinder, or other means. Various sizes are available, each accommodating different gears within its range.

Aluminum Body Chuck

The *Whiton Machine Co.*, 501 Howard St., New London, Conn. A new aluminum body chuck claimed to have the strength of steel and the wearing qualities of cast iron but with the lightness of aluminum. Present models are made for direct mounting on American standard spindle nose type D-1. The jaws, scroll and pinions are made of heat treated alloy steels. Holding capacity of small precision lathes may be increased due to lighter spindle loads.



This chuck has an aluminum body to increase its holding capacity.

Precision Chuck

Edward Blake Co., 634 Commonwealth Ave., Newton Center 59, Mass. This is a small-lathe precision chuck, similar in many ways to a collet chuck. It does not draw back when closed; can be faced and can be bored after mounting on the lathe. If necessary, jaws can be machined to hold special shapes. Chuck is made for lathes having threaded nose spindles 1½ in.-8 thread.

Collet and Jaw Chuck

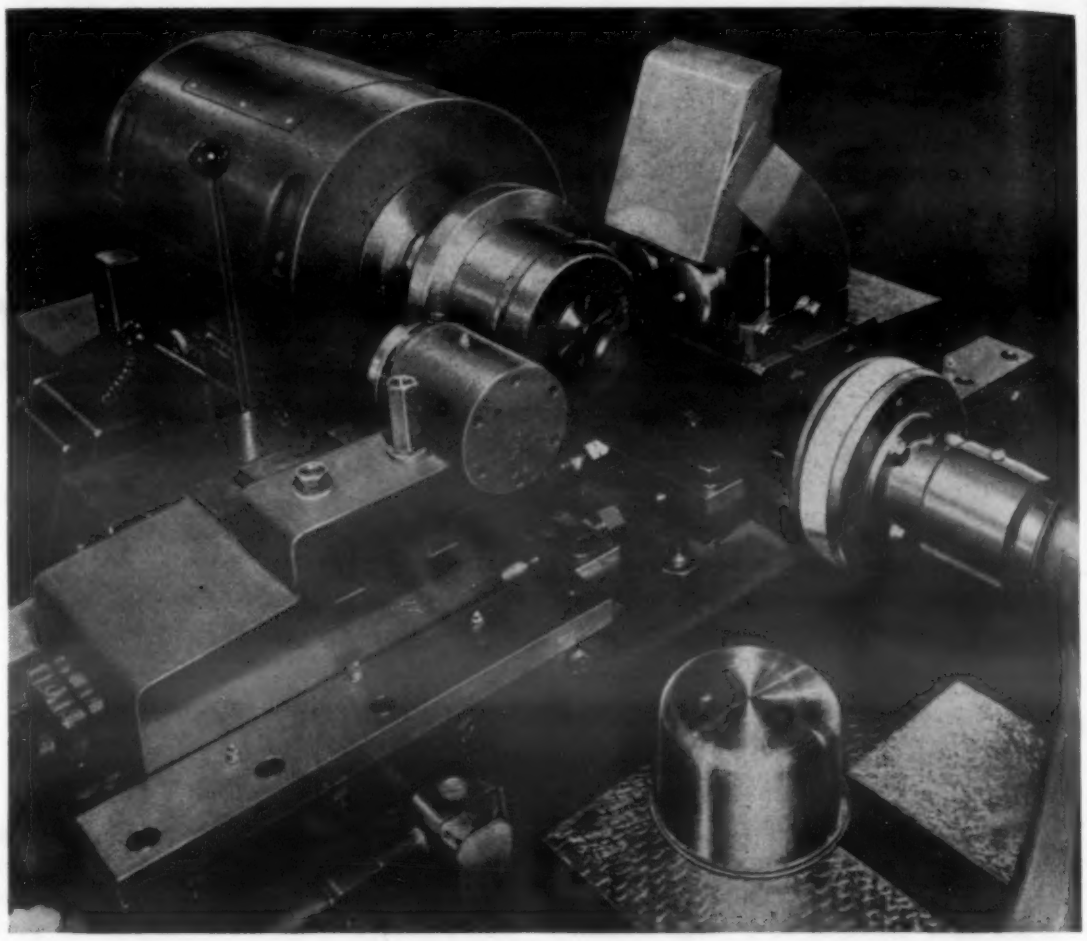
Airo Products Co., 2938 Denby Ave., Los Angeles 26, Calif. The chuck is said to combine the advantages of both the collet and jaw chuck. Is adjustable to concentric or eccentric work and holds round, square or hexagon stock. Capacity is ⅛- to 1-in. round, ⅞-in. hexagon, and ¾-in. square. Adaptable to either engine or turret lathe.

Bench Backstand

Hammond Machinery Builders, Kalamazoo 54, Mich. This backstand converts existing wheel bench grinders into production abrasive belt units. Grinding wear is on the abrasive belt and not on the supporting contact wheel. The abrasive belt cuts cooler because there is less pressure applied while grinding, and the grinding is done over the greater abrasive area. Is available for left hand and right hand operation.

Cross-Slide Attachment

E. W. Bliss Co., 450 Amsterdam, Detroit. An independently operated hydraulic cross-slide attachment for second operation spinning lathes. It is timed to enable trim cutters in the rear of the attachment to move in on the part and trim the edge. The cutters, upon completion of their work, automatically retreat, allowing the beading or curling attachments their turn at the part. After completion of their operation, curling and beading attachments return to their original position.



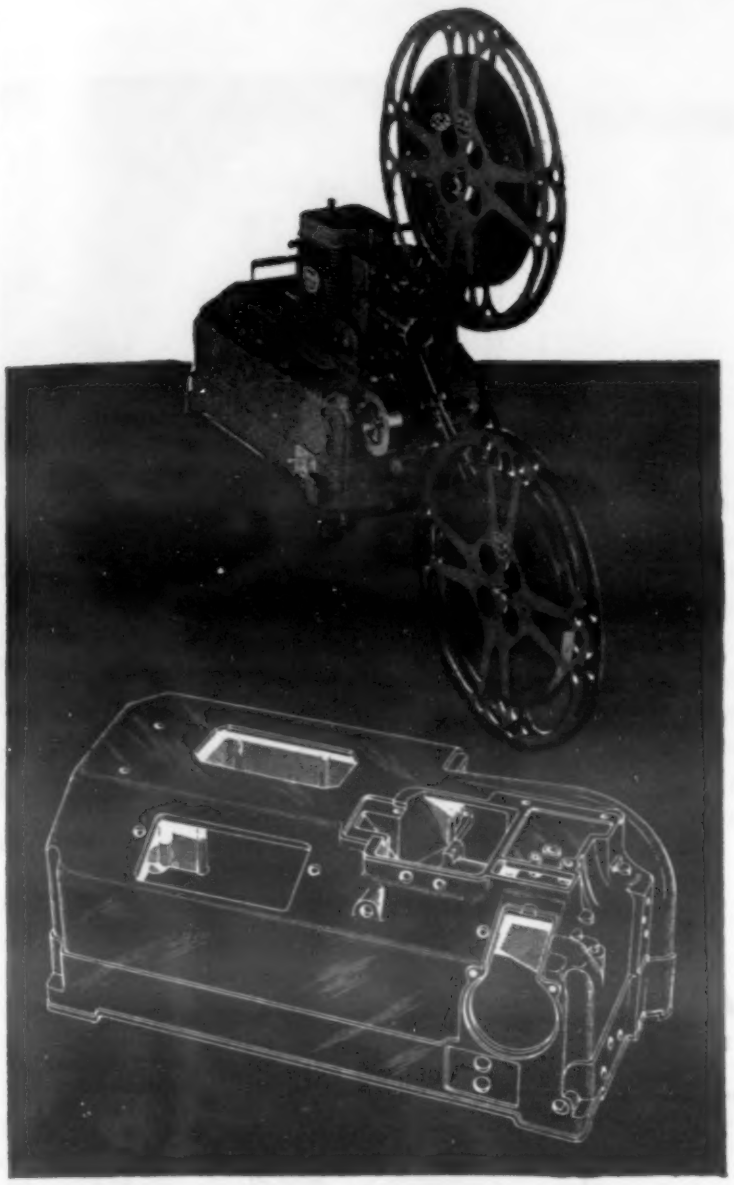
Close-up of independently operated hydraulic cross-slide attachment for second operation spinning lathes.

Turret Attachment

Artesan Tool & Cutter Co., 531 Vester St., Ferndale 20, Mich. This attachment is for boring of tapers and profile holes with turret lathes and hand screw machines. Either tapered or straight holes can be bored without making any change in the set-up except for moving back the top slide. The size and taper at the face of the stock are held the same from piece to piece, regardless of variations in the length of the stock.

Turning and Cutting Tool

The *Millholland Screw Products Corp.*, 130 W. 13th St., Indianapolis 2, Ind. This metal turning and cutting tool can be used to convert drill presses, woodworking lathes and grinder stands into precision metal



INTRICACY IS NO PROBLEM

In designing die castings the goal should be simplicity—in the sense that all non-essentials are eliminated—but complexity of shape can be a definite advantage if it results in overall production economies. For example, consider the motion picture projector housing here illustrated. *This is a one-piece zinc alloy die casting.*

Any other method of production for this housing would have entailed either a built-up assembly of a number of parts or exorbitant machining costs. As a die casting, the holes, recesses, bosses and intricate contours are achieved in a single operation and very little additional work beyond trimming is required prior to the application of a decorative finish. The obvious savings in machining and assembling easily compensate for the extra tooling costs and slower casting speeds involved in die casting a piece of such complexity.

In die casting there is no scrap loss and, since the average wall thickness of this housing is not much over 1/16", an absolute minimum of metal is consumed. An additional advantage is the smooth as-cast surfaces which facilitate the application of a handsome wrinkle lacquer finish.

ALLOY SELECTION

Good die casting design is of no avail unless the proper alloy is selected. Furthermore, it is imperative that any alloy used in die casting production be carefully formulated with respect to every element involved to insure maximum mechanical properties and dimensional stability. If a zinc alloy is used, your die caster should provide one of those shown in the table below. These alloys are covered by specifications of the American Society for Testing Materials and the Society of Automotive Engineers.

Composition of Zinc Alloys For Die Castings

Composition* % by Weight	ZAMAK†-3 A.S.T.M.-XXIII S.A.E.-903	ZAMAK†-5 A.S.T.M.-XXV S.A.E.-925
Copper	.10 Max.	.75 to 1.25
Aluminum	3.5 to 4.3	3.5 to 4.3
Magnesium	.03 to .08	.03 to .08
Iron, Max.	.100	.100
Lead, Max.	.007	.007
Cadmium, Max.	.005	.005
Tin, Max.	.005	.005
Zinc	Remainder	Remainder

*Composition as provided in A.S.T.M. and S.A.E. Specifications. The Zamak alloys meet these specifications but are held within closer limits as to composition.
† A trade mark (registered in the U. S. Patent Office) identifying the zinc alloys developed by The New Jersey Zinc Company and used in the die casting industry.

For additional data on die casting design ask us—or your die casting source—for a copy of the booklet "Designing For Die Casting".

Send for your copy ➡

The New Jersey Zinc Company, 160 Front St., New York 7, N. Y.

ZINC FOR DIE CASTING ALLOYS

The Research was done, the Alloys were developed, and most Die Castings are based on

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YOUR NAME'S IN THE POT

When you order STRENES METAL dies from us, they are distinctively yours in metallurgical structure.

By varying cupola changes, we are able to give each batch of STRENES METAL special characteristics in respect to hardness, toughness, density, temperability, acid resistance, magnetic qualities, etc. Knowing the drawing and forming problem, we mix the ingredients of STRENES METAL to meet the requirements.

This explains why STRENES METAL dies deliver an extraordinary number of stampings between redressings, thereby greatly cutting maintenance and production costs.

It will pay you to find out how the advantages of STRENES METAL dies are applicable to your drawing and forming operations. Ask us for specific information.

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STRENES METAL
DRAWING AND FORMING DIES

INVESTING?
The KERR VACUMATIC *is your answer!*

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. . . the solution to the bottleneck created by old-style, low-vacuum pumps. This unit will evacuate a bell jar 8" x 5" in about five seconds! — to a vacuum of 29.6", (about 3 times as high a vacuum as 29.0").

The "Vacumatic" consists of a motor (¾ to 2 hp.), Nitralloy pump, and piping and valving details, all efficiently mounted in an attractive black and grey steel cabinet. The 18" x 18" joggle plate will accommodate bell jars up to 16" in diameter.

Available with either one or two vacuum stations, A.C. or D.C., in any desired line voltage.

See the **KERR VACUMATIC** in our new catalog "Precision Casting by the Lost Wax Process" — 32 pages of information, equipment and "know-how". Send for your *FREE* copy today!

★ **I. SHOR**
EST. 1918

Precision Casting Sales and Engineering
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Dept. M.

working lathes. Has a built-in micrometer; it handles ½-, ⅜- and ¼-in. brass, aluminum and steel bar stock, and turns multiple diameters.

A drill press converted into a lathe by use of the turning and cutting tool.

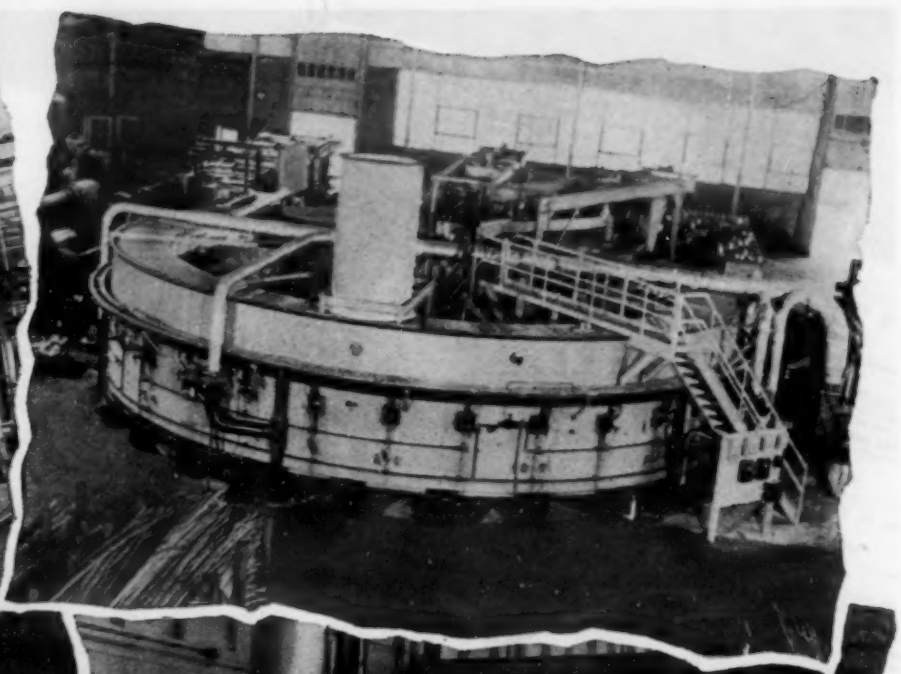
Profile Grinding Machine Combined with Optical Comparator

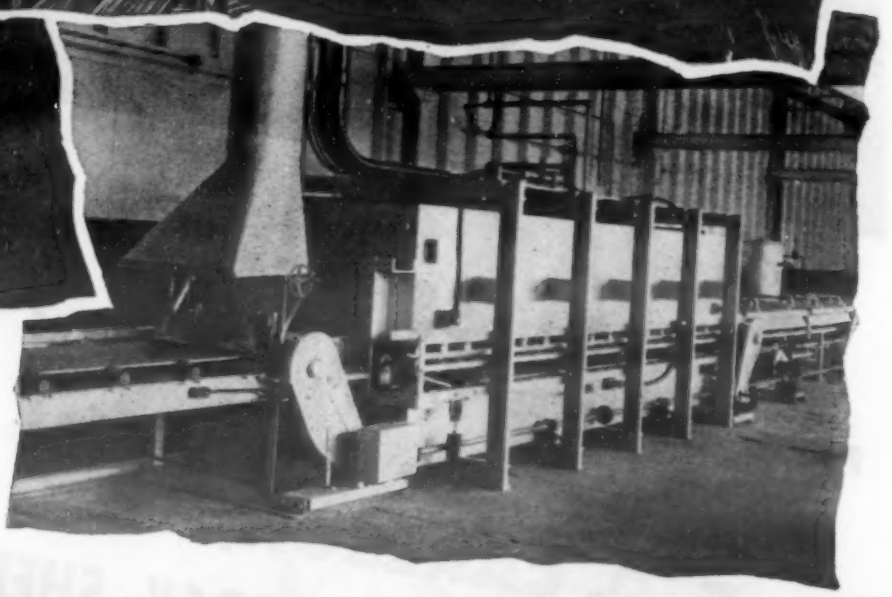
A new grinding machine for the grinding of accurate small profile shapes has been developed by the *Cincinnati Milling Machine Co.*, Cincinnati 9, Ohio. It provides an optically enlarged image of the work, which may be compared as grinding progresses with a previously prepared, enlarged scale master drawing. In effect, the machine combines the dual purposes of profile grinding machine and optical comparator.

The workpiece may be positioned in relation to the optical system by means of longitudinal, transverse, and vertical slides, and a swivel movement of the work platen provides for angular adjustments of the work. These movements provide the means for accurately locating the projected image in relation to the master drawing, and are accomplished by means of hand positioning ballcranks. Micrometer dials are not supplied for these adjustments since positioning of the work is accomplished by visual observation of its projected image.

The grinding wheelhead is carried on transverse and vertical slides to provide adjustment of the grinding wheel in relation to the workpiece. The handwheel controls for these slides are carried on a bracket which projects from the front of the machine at operating position in front of the viewing screen.

Each slide is controlled by a pair of handwheels, a large one for rough positioning and a small one for fine adjustments. The small handwheel provides extremely sensitive positioning of the grinding wheel since the wheel is moved only 0.001 in. for each complete revolution of the handwheel.





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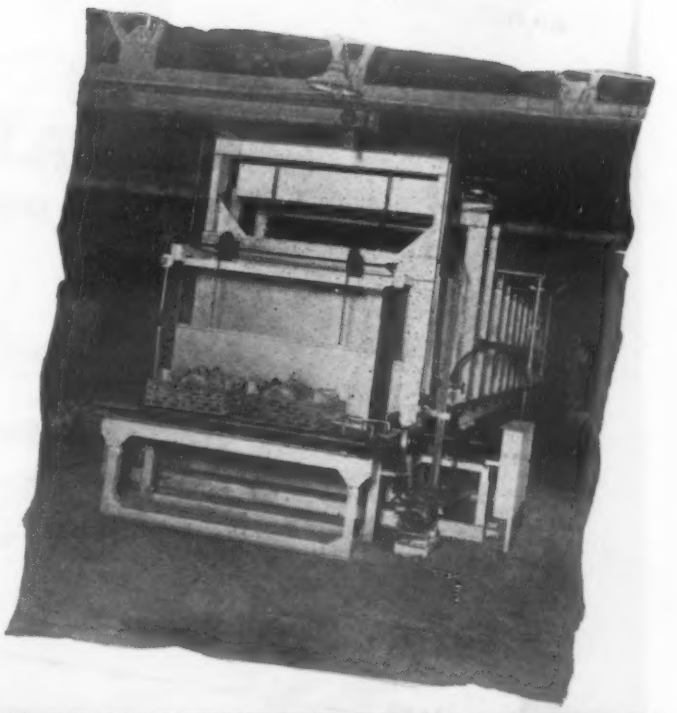
for any heat treating requirement

● EF furnaces are built in many different types—suited for performing a wide variety of different heat treating processes. They are available in sizes to meet any capacity requirement, and reflect the advantage of the many service-proved features conceived and perfected by EF engineers, during the company's 30 years experience,—and available only in EF furnaces. These include the EF radiant tube, EF heat exchanger, EF alloy steel electric grids, EF roller design and mounting, EF atmosphere generators and many other devices that assure uniform temperature throughout the furnace—more accurate control of the heat within the required limits, low stack temperatures, increased outputs, reduced maintenance, and uniform, low cost, dependable operation.

Investigate the EF advantages—and let EF engineers, with their long and outstandingly successful record, work with you on your next heat treating job.



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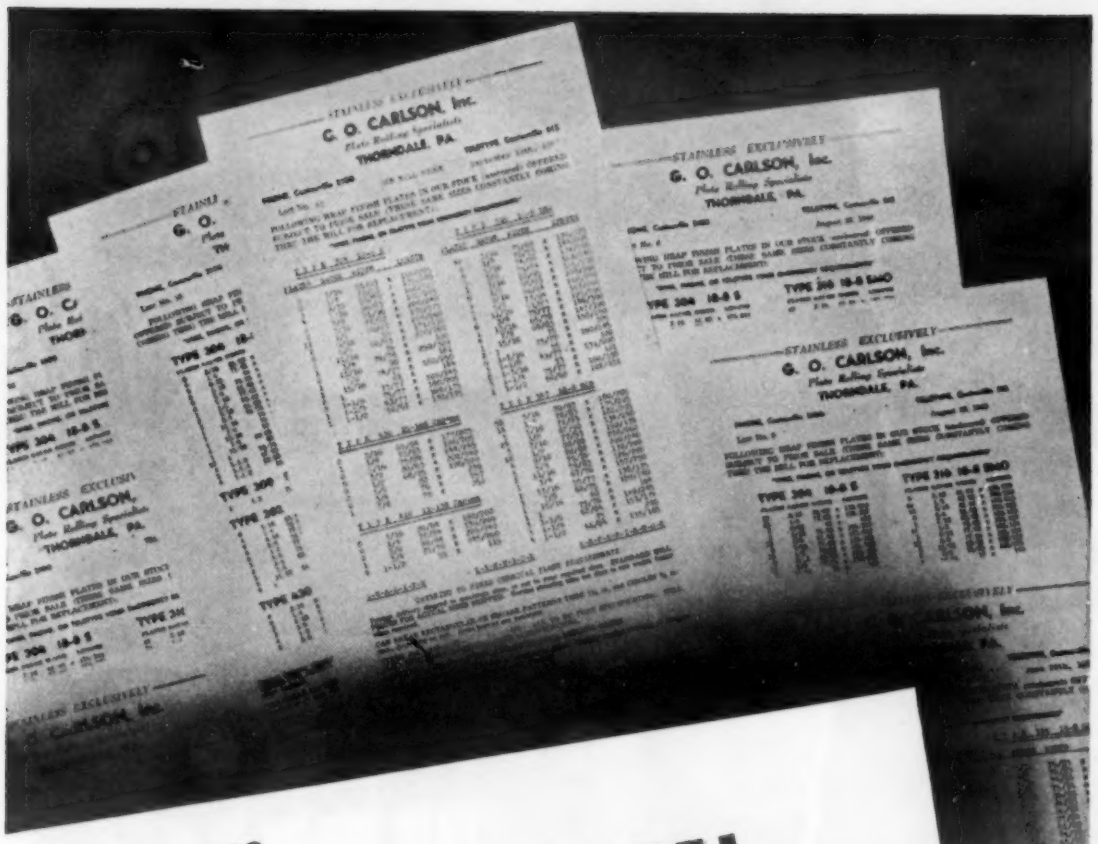
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Even the largest stock of stainless plate in the country changes from week to week—so G. O. Carlson, Inc. gives you the actual stock on hand each week—mailed to you each Friday at no cost to you.
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FILL OUT AND SEND US THIS CONVENIENT FORM
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Please put my name on your list to receive your weekly stock list of stainless steels.
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CITY

Developments in Cutting and Lubricating Compounds

Tapping and Threading Oils

A new tapping compound and threading oils for use in tapping and threading of ferrous metal, including stainless steels, and aluminum, have been announced by the *James L. McManus Co.*, 2121 South Wabash Ave., Chicago 16, Ill. The tapping compound, a blended chemically neutral combination of animal and mineral lubricants, is non-toxic and contains no white lead or lead derivatives.

It is a viscous material intended for brush application. The rate of conversion to oil is directly in proportion to heat generated by the cutting tool, thus giving sufficient lubricant to the lead threads of the tap and permitting it to cut free. While developed for use as a tapping and threading lubricant, the tapping compound can be used as an additive to chlorinated and sulfurized mineral base cutting oils at present employed.

The threading oil is recommended for high-speed machine tapping where a less viscous product is needed for continuous flow systems.

Drawing Compounds

A series of lubricating compounds developed especially as modern lubricants for drawing, sheeting and stamping nonferrous metals is being manufactured by *Glyco Products Co., Inc.*, 26 Court St., Brooklyn, N. Y. These compounds provide a film which acts as a temporary corrosion inhibitor, and permit continuous lubrication. They are available in various forms, ranging from liquids to solids and from water-soluble or water-dispersable materials to oil-soluble materials. One compound in the series of 12 compounds is both water and oil dispersable.

For wet drawing, a solution of 2 to 5% compound and water usually is the most satisfactory. In some processes, the stock to be drawn dry may be dipped into the solution before the operation, then allowed to dry and then processed. This makes possible reduction of the amount of lubrication at the die.

Sulfur Cutting Oil

A cutting oil combining active sulfur content with absence of disagreeable odor has been announced by *Gulf Oil Corp.*, Pittsburgh. The sulfur in these oils is chemically combined by a process so that it is active over the entire range of a cutting operation. Their efficiency is ascribed to the fact that the amount of chemically active sulfur (rather than the total percentage of sulfur contained) governs cutting oil performance.

The overcoming of disagreeable odor is said to make available the advantages of these highly chemically-active sulfur oils to all types of operations with assurance of pleasant operating conditions.

Cutting Coolant

A liquid concentrate used with 10 to 75 parts water for high-speed production of tough alloys has been announced by *Anderson Oil Co., Inc.*, Portland, Conn. According to the manufacturer, the coolant is a

I'm *Doc Tillity*, one of Federated's friendly service men. Me and the other Federated service boys have worked with metals for quite a while now and . . . we know our stuff. What's more, we're ready to prove it to you any time you run into a metal problem, big or little.

Federated is a right large outfit— first in the whole non-ferrous field— and they're anxious to have us service men roll up our sleeves and help you out whenever you ask.

Remember, boys, for service . . . for anything in the non-ferrous metals line, call Federated first. Our offices are all over the country.

I'll be seeing you and talking to you again pretty soon. So long for now.

JMLco F-L1

the use of AJAX PHOSPHOR-COPPER

15 STANDARD ALLOYS BY AJAX

Ajax Tombasil
Ajax Plastic Bronze
Ajax Anti-Acid Bronze
Ajax Phosphor Bronze
Ajax Red Brass Ingots
Ajax Manganese Bronze
Ajax High-Tensile Manganese Bronze
Ajax Golden Glow Yellow Brass
Ajax Nickel-Copper 50-50%
Ajax Manganese Copper
Ajax Aluminum Alloys
Ajax Phosphor Copper
Ajax Silicon Copper
Ajax Nickel Alloys
Ajax Phosphor Tin

Send for booklet "Ingot Metals of Today"

•

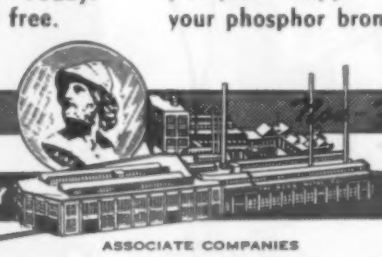
NOTE: * "Proper Melting Decreases Foundry Losses," contains interesting data. Also, the booklet, "Nonferrous Ingot Metals of Today." Write for both. They are free.

Successful foundrymen deoxidize or "clean up" molten metal by a scientific method worth using as indicated:

They use phosphorus . . . expertly . . . in the form of "Ajax Phosphor Copper" . . . added as the crucible is removed from the furnace . . . for virtually all brass and bronze alloys.

In notched waffle sections, or in shot form, Ajax 15% P-Cu does its work at .01% (1 oz. per 100 lbs.). Introduced, and having time to react when stirred with a whirling motion of the skimmer, it causes oxides to rise for effective removal by skimming from the surface. It is best to avoid phosphorus build-up from back stock.*

If you use phosphorus these days, use Ajax phosphor Copper (useful also in producing your phosphor bronze).



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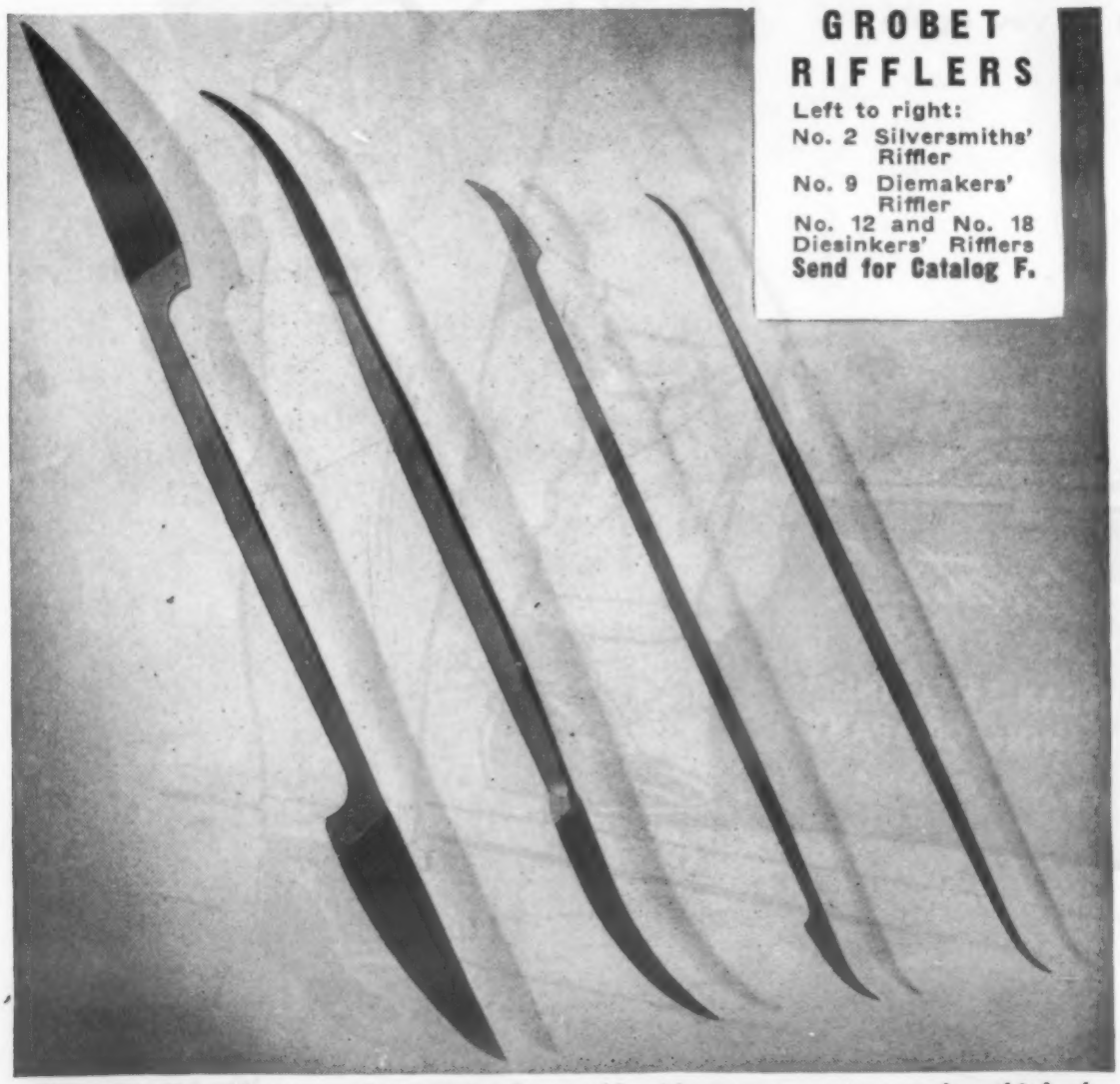

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No. 12 and No. 18 Diesinkers' Rifflers
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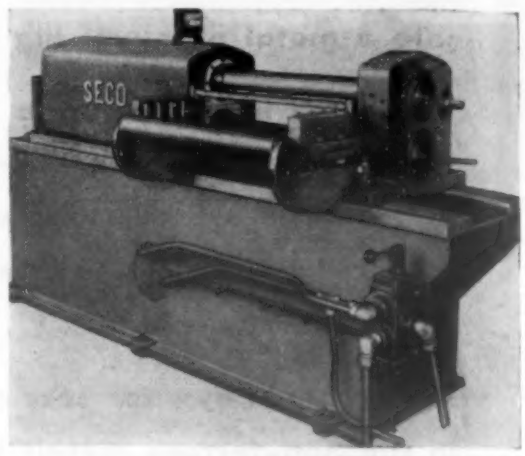
true solution, not an emulsion, and neither evaporates nor becomes rancid. It is said to have low interfacial tension and because of this is able to get between the tool and the chip with unusual rapidity and thereby prevent the formation of heat.

Slitting Line Uses Hydraulic Power

A slitting line operated entirely by hydraulic power has been designed and built by the *Steel Equipment Co.*, Cleveland, Ohio. All units of the new line are driven by fluid motors, hydraulic power being supplied by one hydraulic pumping unit using a variable delivery pump driven by a constant speed a.c. motor. Volume control



The use of hydraulic power enables good control over speed range.

permits the operator to bring the speed down for threading-in operation at about 35 ft. per min. The line can be accelerated to top speed or slowed down without use of any brakes.

Tension regulation of the recoil reel is accomplished through pressure control. Payoff and rewind reel blocks are expanded and collapsed using hydraulic cylinders which act upon a push-pull rod. All coil handling equipment is operated by means of hydraulic cylinders.

Bench Miller Features Large Table

A bench mill, weighing 450 lb., and featuring a 4⅛- by 20-in. table, with a longitudinal travel of 12 in., a vertical travel of 9 in. and transverse travel of 6 in., has been announced by *Diamond Machine Tool Co.*, 3429 E. Olympic Blvd., Los Angeles 23, Calif. Three table tee slots are provided to mount work to best advantage. The heat-treated spindle is mounted in tapered roller bearings and is equipped with No. 9 B&S taper. Spindle nose is hardened and ground for perfect concentricity and finish.

Power is transferred to the spindle by means of a three-step pulley with double "B" V-belts. A bracket supporting the jackshaft is arranged for rapid belt shifting and tension adjustment. Speed range of the spindle varies from approximately 100 to 1400 rpm.

What does your product need to make it easier to sell?

Does it need resistance to corrosion?

Tanks and ductwork, metal cabinets, refrigerating, ventilating and air conditioning equipment, etc., that are prone to rust can be built to last longer by using U·S·S Copper Steel. Costing only 5% more than plain steel, it offers double the resistance to atmospheric corrosion. When even greater resistance to atmospheric corrosion is needed, U·S·S Cor-Ten will provide it at reasonable cost. And where corrosive conditions are especially severe, U·S·S Stainless Steel will give resistance unsurpassed by any other commercial metal.

Must it be strong yet light in weight?

Used in buses, trolley coaches, trucks and trailers, in freight and passenger cars, and in fact in all kinds of mobile equipment, U·S·S Cor-Ten—the pioneer low-alloy, high-strength steel—will trim off hundreds of pounds of dead weight, yet at the same time will provide increased structural strength and ruggedness. U·S·S Cor-Ten costs so little more than plain steel and fabricates so readily that these benefits can be obtained at little or no increase in cost. When the ultimate in weight reduction is desired, and its higher cost is justified, U·S·S Stainless Steel will permit even more drastic savings in weight.

Does it need greater ruggedness?

In heavy duty equipment like this, U·S·S High Strength Steels—such as U·S·S Cor-Ten and U·S·S Man-Ten—used in structural members and body plates will provide stamina with the least increase in cost. In gears, axles and bearings where stress is concentrated, U·S·S Carilloy Steels will provide maximum endurance with minimum weight. No other manufacturer of alloy steels can offer you such a complete range of form, dimension and treatment.

Are good looks important?

In household equipment of all kinds—refrigerators, stoves, washing machines, etc.—porcelain enamel on steel adds beauty, cleanliness and the ability to stay new that women appreciate. Its resistance to chemical action, to moisture, and heat are added advantages that recommend its use in food plant equipment, in bakery and dairy apparatus, and for shower and toilet partitions and wall panels. U·S·S Vitrenamel is an improved steel base for porcelain enameling that insures maximum life and permanent good looks. In knives, table tops, kitchen sinks, in pots and pans and electrical appliances U·S·S Stainless Steel combines irresistible eye-appeal with unmatched durability

9 times out of 10 STEEL will do it better

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United States Steel Supply Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

USS STEEL — UNITED STATES STEEL

UNITED STATES STEEL

Check CO_2 Efficiently!

Engelhard portable CO_2 Gas Analyser permits quick determination of heat treating furnace conditions efficiently, without taking samples of combustion gases back to the laboratory. This means that furnace atmosphere conditions are known instantly and any necessary furnace adjustments can be made on the job with visual measurement on a direct reading meter.

This FLUALYZER, as we like to call it, is an instrument incorporating sensitivity, ruggedness and complete portability. The ENGELHARD thermal conductivity method of gas analysis assures highest accuracy. To complete the setup, temperature readings of flue gases can also be taken with the same instrument, if you desire.

Write for prices and Bulletin 700

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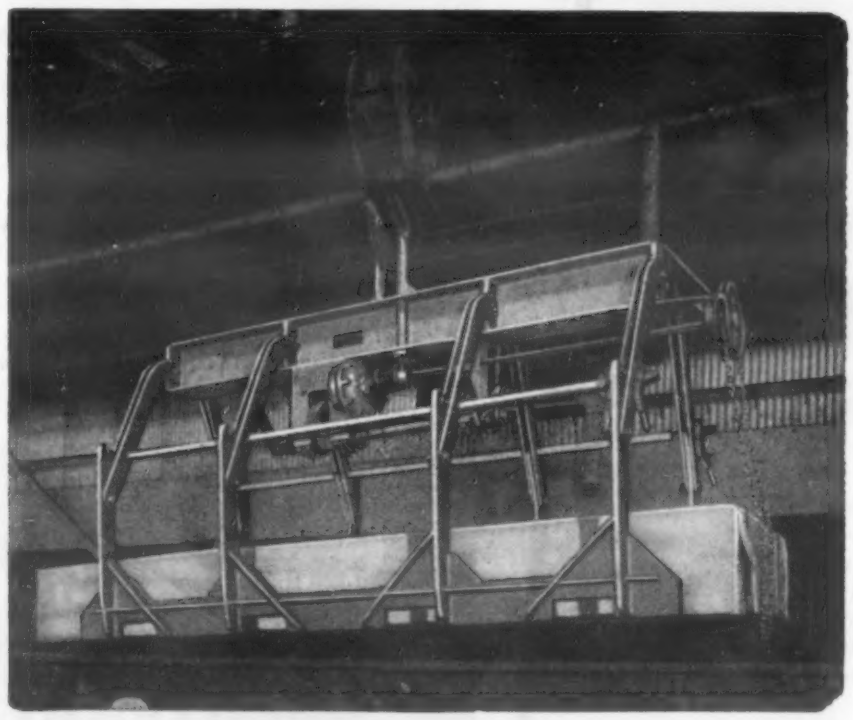


When carloads of sheet stock are unloaded at the receiving room, actual manufacturing costs begin. But, when sheet stock is unloaded and carried into storage or to machines with C-F Sheet Lifters, these costs are minimized — stock damage is eliminated and your end profit begins. Because C-F Sheet Lifters, under one man end or remote cab control, handle more sheets per load, safer, faster and more economically, they are the logical answer to the demand for modern, low cost materials handling.

There are C-F Lifters in capacities from 2 to 60 tons or larger, in standard or semi-special designs to meet any sheet or materials handling requirement.

Write for Bulletin SL 23,

CULLEN-FRIESTEDT, 1314 S. Kilbourn Ave., Chicago 23, Ill.

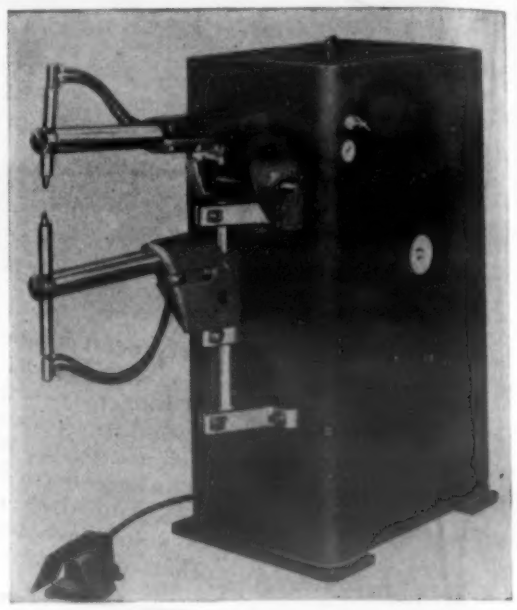
CULLEN-FRIESTEDT, CHICAGO 23, ILL.

C-F positioned welds mean better, more economical welds

Spot Welder for 16-Gage Steel and Lighter

A newly designed 50-kva. spot welder is being manufactured by *Banner Products Co.*, 4951 N. 29th St., Milwaukee 9, Wis. The welder has eight ranges of heat selection, water cooled transformer, and high conduction and high strength current carrying castings.

On long production runs where repeat operation is used, the free action of welder and low inertia of rocker arm enable operator to positively space spots to produce a clean, uniform job. Unit is adaptable to a variety of jobs, and lends itself to both the job shop and assembly line.



The spot welder shown here is made for foot or air operation.

The arms are 2½-in. dia. hard-drawn copper. The machine has a throat of 12, 24, or 36 in. and a 2½-in. stroke. It can be used for welding 16-gage clean mild steel or lighter.

Lens Assembly Increases Optical Pyrometer Image Size

A new objective lens assembly for optical pyrometers is available from the *Leeds & Northrup Co.*, 4934 Stenton Ave., Philadelphia 44. The size of the image that an operator sees in these assemblies can be made twice as large as the standard instrument provides.

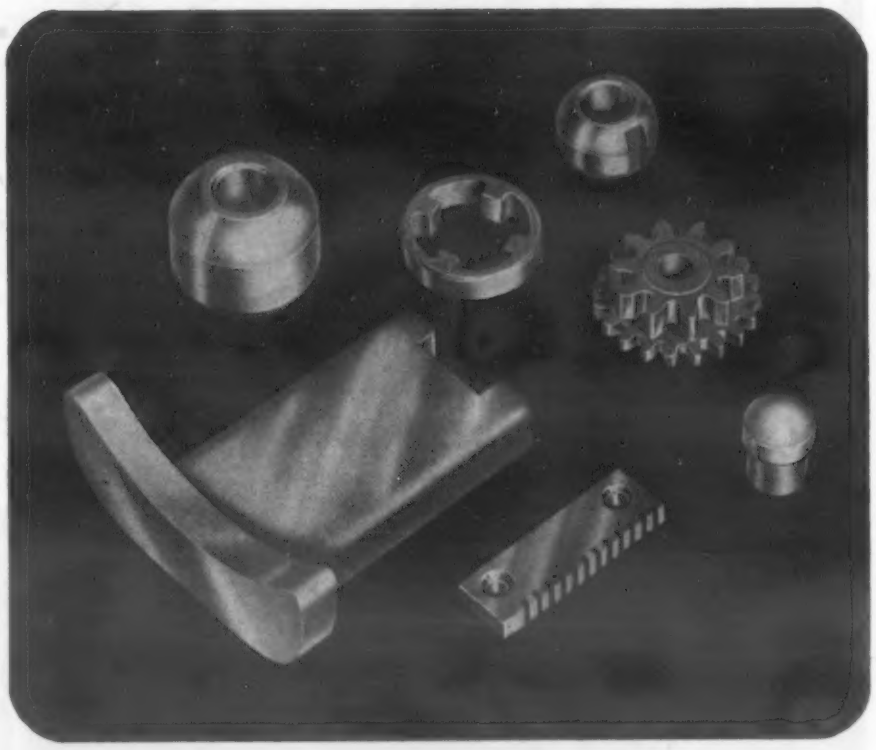
This increased size is particularly useful in measuring the temperature of thin or small-area objects. It makes the brightness match between the hot object and the optical's "disappearing filament" considerably easier to obtain, in cases where the target would otherwise appear almost as small as the filament.

Typical applications where the larger image is handy in open hearth shops are in measuring tapping temperatures by sighting at the darker streak at the center of the tapping stream, and in reading temperature during spoon tests by sighting at the narrow ribbon of metal pouring from the spoon.

gramix bearings keep Roper Pumps operating smoothly to insure reputation for dependability

GRAMIX powder metal bearings are helping the Geo. D. Roper Corp. of Rockford, Ill., to maintain *its 90-year-old reputation for dependability in pumps.* For example, in the back plate and packing gland of the Roper Series K Rotary Pumps, GRAMIX drive shaft bearings *operate flawlessly* at operating speeds of 1740 R.P.M. and *eliminate* the use of pedestal bearings. In the "Roper-PAC" Hydraulic Unit for farm tractor installations, GRAMIX bearings are employed *in the idler gear,* on the main shaft *in the face plate, in the sub-plate* to carry a portion of the drive shaft radial load, and *on the drive shaft* to carry loads imposed by chain or belt drive. These GRAMIX bearings *operate dependably* at pump speeds of 1000 R.P.M. and *are lubricated by the liquid being pumped.*

gramix



GRAMIX powder metal bearings, small gears, and machine parts are helping many manufacturers achieve *new standards of dependability* for their products—*economically!* Die-pressed to exact size from powdered metal, GRAMIX parts *reduce production costs* because they require no costly machining or hand finishing. They are *porous* to permit impregnation with lubricant which lasts the life of the installation. They may be made in a *wide variety* of shapes and sizes. Send us sketches of your products and we will show you where GRAMIX will improve mechanical performance and save you money. Write today for *your* copy of the *big, new, 260 page* GRAMIX catalog.

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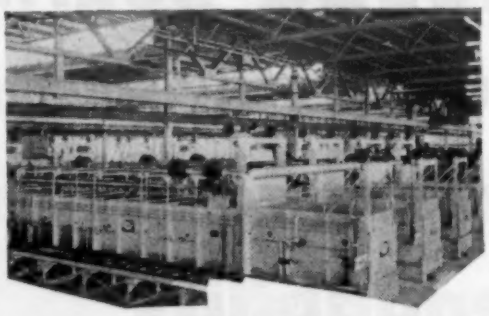

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Stiffness Tester Is Motor-Driven

A new motor-driven stiffness tester, designed for tests on light metals, foil, paper, plastics, textiles, leather, hard rubber, fibre products, and other thin flexible sheet materials, has been developed by *W. & L. E. Gurley*, Troy, N. Y. The tester measures the stiffness, or absence of it, of practically any thin flexible sheet material, and its capacity is from light tissue paper or thin cloth up to the heaviest single sheet boxboards in common use, and it can also be used for light metal and foil testing.

The stiffness tester has a balanced pointer which pivots in jewel bearings, and moves parallel to a sine scale mounted on the base. It is loaded below the center with weights of 5, 25, 50, or 200 grams, fastened 1, 2, or 4 in. from the pivots.

To make a test a sample is first cut to a standard width and length (½, 1 or 2 in. wide, and from ½ to 4½ in. long), clamped in a movable clamp so that the free end overlaps the top of the pointer by ¼ in.; and pressed against the top of the pointer until it is bent sufficiently to assume a short arc, shortening it by ¼-in. overlap. The pointer is then automatically released.

The greatest reading of the pointer against the sine scale is averaged in both directions, to eliminate any effects of curl, and may be multiplied by a factor applying to one of 144 combinations of sample and loading weight. The product is expressed as the stiffness of the sample.

Finishings of varnish, paste, lacquer, glue, wax, paraffin, waterproofing, glycerine, oil or other plasticizers can also be measured and evaluated.

● A new liquid coloring composition for coloring nickel, brass, copper, aluminum and zinc die castings has been developed by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J. It is said to leave the face of the buff soft and clear and does not clog fluid lines.

New Corrosion Resistant Pipe for Industry

The development of a new type of corrosion resistant pipe and fittings has been announced by the *Dow Chemical Co.*, Midland, Mich. The product, Saran-lined steel pipe, is designed to convey corrosive liquids, and its main use is in manufacturing chemicals, metal treating and metal plating, where manufacturing methods necessitate handling highly corrosive chemicals, particularly acids.

The pipe will satisfactorily carry corrosive sulfuric, hydrochloric, nitric and phosphoric acids. The working temperature of the pipe ranges from 0 to 190 F, depending upon service conditions.

Pipe in maximum lengths of 10 ft. and in sizes from 1 to 4 in. will be manufactured. Fittings include elbows and tees, companion and reducing flanges and gaskets.

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any information about
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"The Influence of Minor Elements on Heat Resistance of Standard Alloys" is the latest addition to the Cerium File Folder. It is available on request.
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On any application involving cutting tools, drawing dies, or wear parts in your plant, you can up your production many times over by using Talide Tungsten Carbide.

For example, cutting tools of Talide cut 2 to 3 times faster than high speed tool steel. Likewise dies and wear resistance parts outwear steel by as much as 50 to 1. Use Talide Metal wherever steel parts wear too fast or service is too severe for steel.

Properly applied, Talide Metal's original cost is no factor as proved by experience of the past 15 years in all types of industrial applications. Let our sales engineers give you full particulars and recommendations.

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(double that of steel)

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YOUNGSTOWN 5, OHIO *Pioneers in Tungsten Carbide Metallurgy*

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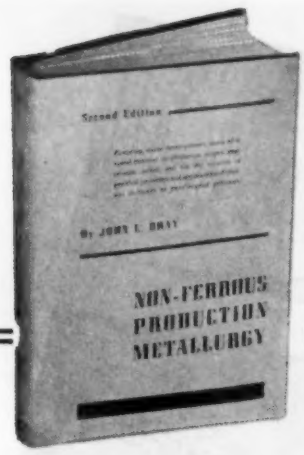

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for processing low-grade ores
for getting a purer yield

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Second Edition

By JOHN L. BRAY, *Head, School of Chemical & Metallurgical Engineering, Purdue University*

From the practical standpoint of methods, processes, and applications, this new edition of *NON-FERROUS PRODUCTION METALLURGY* is your best guide to the most modern and efficient production operations. Professor Bray points out the tremendous advances that have taken place in the copper, aluminum, magnesium and other industries, and discusses the up-to-the-minute information that has resulted from wartime research and development.

The second edition features recent developments, much additional material on aluminum, copper, magnesium, nickel and tin; the solution of practical problems; and applications of physical chemistry to metallurgical processes.

Contents include: I. Introduction. II. Metals and Ores. III. Slags and Fluxes. IV. Aluminum. V. Antimony. VI. Arsenic. VII. Beryllium. VIII. Bismuth. IX. Cadmium. X. Chromium. XI. Cobalt. XII. Copper. XIII. Gold. XIV. Lead. XV. Magnesium. XVI. Manganese. XVII. Mercury. XVIII. Molybdenum. XIX. Nickel. XX. Platinum. XXI. Selenium and Tellurium. XXII. Silver. XXIII. Tin. XXIV. Tungsten. XXV. Vanadium. XXVI. Zinc. XXVII. Secondary Metals. XXVIII. Marketing of Bullion, Ores, and Concentrates. XXIX. The Use of Physical Chemistry in Metallurgical Processes. Index.

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New Compounds Cut Buffing Time

A new series of buffing compounds recently announced by the *Hydro Chemical Co.*, 24 East Hartford, Conn., is said to decrease buffing time on both ferrous and nonferrous metals. The compounds constitute no fire hazard since they are noninflammable and are soluble in all proportions in the chlorinated hydrocarbons. They are suited for plants equipped for vapor-phase degreasing operations and are also readily removed in the water-phase cleaning cycle.

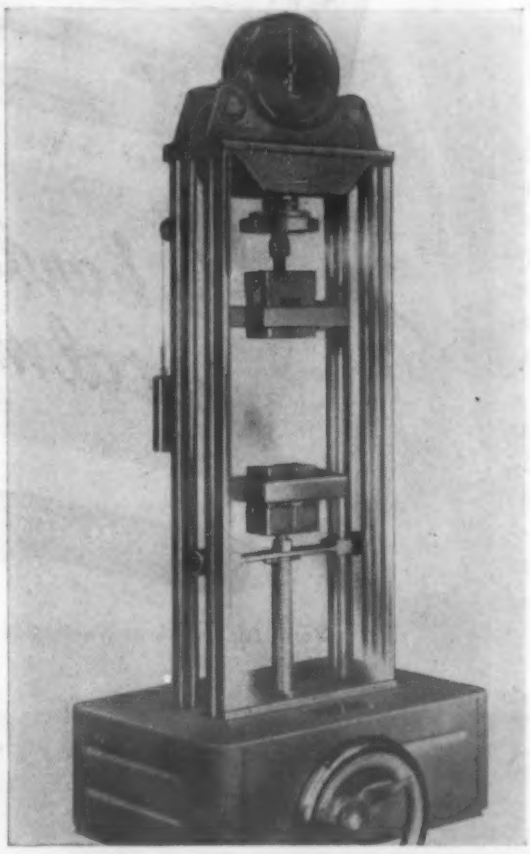
The retention of the compound on buffing wheels is good; it cuts and colors in the same operation, eliminating the need for rouge; and the film remaining on the piece, before cleaning, will protect against oxidation and staining for long periods of time.

New Tester Handles Larger Specimens

Testing larger specimens, as well as specimens that show considerable stretch, are the features claimed for this new physical tester by *W. C. Dillon & Co., Inc.*, 5410 West Harrison St., Chicago 44. The uprights have been lengthened to give a 13-in. spread between grips. A keyless power screw, which is prevented from turning by means of a special, ball bearing-held yoke, permits smooth operation.

Additional features are the hardened steel sleeve to guide power screw, cast aluminum gear housing, ball bearing power shaft supports, and an improved shock absorber screw. Grips are quickly interchanged to handle tensile, transverse, compression, or shear tests.

The Model L is available in seven ranges: 0-25 lb., 0-500 lb., 0-1000 lb., 0-2500 lb., 0-7500 lb., and 0-10,000 lb.



This materials tester is especially suitable for long specimens, and specimens with considerable stretch.

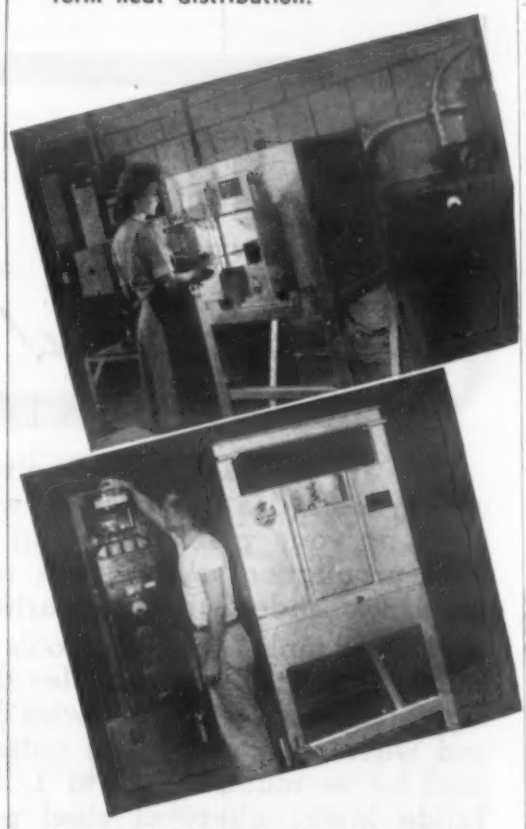
QUESTIONS AND ANSWERS ABOUT

Harper

ELECTRIC FURNACES

10. Who Uses Them?

The Who's Who of American business depends on the performance of Harper Electric Furnaces. Their success in exacting laboratory research and critical production operations has proved their accurate temperature control and uniform heat distribution.



Upper photograph shows Harper furnace in research and quality control laboratory of leading abrasive manufacturer.

Lower photo shows Harper furnace annealing fused quartz parts in large radio and electronic equipment plant.

Harper Electric Furnaces are built in a wide range of types, sizes and capacities to meet laboratory and production requirements. Write for data.

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WHAT HAS MY PRODUCT IN COMMON WITH ALUMINUM BUILDINGS?

PLENTY, if you're looking for proof how a product, in a highly competitive market, can be given the advantages of aluminum at little or no increase in cost.

This new prefabricated farm and utility building is all-aluminum inside and out, never requires paint, is fire and vermin proof. The common assumption would be that its price is "out of this world" compared to steel. Actually, there's little or no difference in the final erected cost.

And that's where manufacturers are guilty of a common error in evaluating aluminum. They forget that pound for pound aluminum gives *three times* the working area of steel, brass or copper—often overlook the economies of handling and assembling this lightweight material, which, in the case of this building, cut erection costs in half. And, even more important, they fail to take into consideration that aluminum is available for immediate delivery at the lowest prices in history.

The true cost of aluminum doesn't stop with a price per pound quotation. Consideration of all the factors may disclose that you can't afford *not* to use this modern metal. The services of a Reynolds technician to aid you in this study are yours for the asking. Write Reynolds Metals Company, 2560 South Third Street, Louisville 1, Kentucky.

The price of aluminum has been reduced 30% since Reynolds became a primary producer in 1939.

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THE GREAT NEW SOURCE OF **ALUMINUM**

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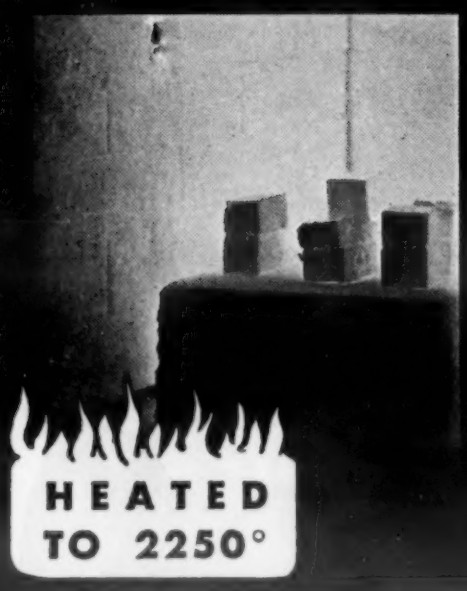

Brickseal provides a crackproof, vitrified armor for furnace linings. The small firebricks shown in the furnace were bonded and painted with Brickseal and heated to 2250°. Directly from the furnace they were plunged into cold water as shown below—a test for *any* material subject to expansion and contraction.

Brickseal is *semi-plastic when hot,* yet *hard and tough when cold.* Brickseal is made in grades suitable to heats ranging from 1400° to more than 3000°. It will make any furnace last longer by giving new life to your refractories. Write or call local dealer for a demonstration.

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News of...

ENGINEERS
COMPANIES
SOCIETIES

Engineers

Dr. *Gordon M. Butler, Jr.* has been appointed senior engineer, Research Div., Carborundum Co., having been associate director of Research, Tool & Die Steel Div., and later chief metallurgist, Dunkirk, N. Y. plant, Allegheny Ludlum Steel Corp. He has degrees in metallurgy from the University of Arizona and Massachusetts Institute of Technology.

Rear Admiral *William Granat,* U. S. Navy (retired) has joined Lester B. Knight & Associates, Inc., consulting engineers, Chicago. He has a well-rounded experienced industrial background which began with post-graduate work in metallurgy at Lehigh University. Later he was with the U. S. Naval gun factory, Washington, as head of the metallurgical, metallographic, physical and chemical laboratories. More recently he organized and was responsible for the management control and maintenance units of some 70 ordnance stations.

Albert M. Rockwood, mechanical engineer, has joined Battelle Memorial Institute where he will do research on production materials and processes. He has degrees from Harvard and Ohio State and served as engineering officer in the Navy.

John S. Lennox, pioneer in development work on core steels, small dry-type transformers and testing equipment, has retired from the General Electric Co. after 41 years of service.

N. R. Arant, formerly with the melting departments, Universal-Cyclops Steel Corp., has joined the Titanium Alloy Mfg. Co. as development engineer, working in the Western Pennsylvania and Ohio districts. He has had valuable experience with open hearth and electric furnace and alloy practice.

Dr. *R. C. Mason* has become manager, electro-physics department, Westinghouse research laboratories, succeeding *Gaylord W. Penney,* who has been appointed Westinghouse professor of electrical engineering at the Carnegie Institute of Technology. Dr. Mason had been with the atomic energy project in Oak Ridge, Tenn. for the past year. From 1937 to 1939 he did fundamental research in the laboratories of the University of Utrecht, Netherlands.

John Emsley Funnell has become ceramic engineer and economic geologist at the Midwest Research Institute, Kansas City, Mo., having been research ceramist, Products Development Dept., Corning Glass

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"Stuart's SOLVOL* was put in on a trial basis for use in Cincinnati Milling Machines on high carbon alloy steel. High speed alloy cutters were used and it was found that SOLVOL* increased the cutter life three to four times of what they had been getting.

"This customer is well pleased with SOLVOL* and will continue to use it in the future on these machines."

Signed E. J. Graham

* **SOLVOL**

The SUPER Soluble Liquid Cutting Compound

When conventional soluble products fall just short of giving the desired results, and yet conditions of the job seem to call for an emulsion, then the use of Solvol, Stuart's *super* soluble, is indicated. Solvol is more than just a high grade emulsifiable cutting fluid. It is a unique product incorporating extra lubricating qualities which enable it to perform metal cutting jobs beyond the scope of other soluble products. It is a stable, homogeneous compound which mixes readily with water to form an emulsion rich in cutting quality. The performance report above is typical, you can't beat the right Stuart oil correctly applied to the job. Let a trained Stuart representative help you to improve production and quality. SOLVOL literature on request.

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Plymetl will help you increase the performance and salability of your products

Haskelite* Plymetl unites plywood's great rigid strength and light weight with the tensile strength of sheet metal. The many users of Haskelite Plymetl find it a material with a flat, smooth, ripple free surface that adds new eye appeal to the products they use it on.

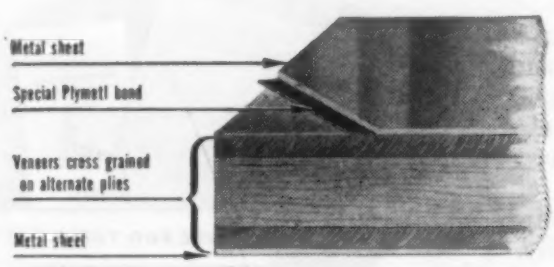
In addition, its great rigidity permits the type of construction that is conspicuous by the absence of numerous or complicated framing members. This factor effects a further saving of deadweight over that already saved through the use of the material itself, and often eliminates man-hours of fabricating time.

If you wish to add a new high standard of eye appeal and reputation building performance to your products — specify Haskelite Plymetl. Write for your free copy of "Plymetl—a material of opportunities."

*T.M. Reg.

CUTS WEIGHT AND BULK — SIMPLIFIES FABRICATION

PLYMETL



Plymetl consists of light gauge metal sheets permanently bonded to one or both sides of a plywood panel. Sheets of zinc coated steel, aluminum or other metals may be used. One type of material may be bonded to one side of the panel, and another type to the other if desired. Panels of Haskelite Plymetl are easily fabricated with simple metal or wood working tools. It may be obtained in a range of thicknesses and sizes to fit specific requirements.

TYPICAL USES

Diesel locomotive side panels, escalator panels, table tops, truck trailer side panels, delivery truck bodies, railway passenger car interiors, bakery proof boxes, bread coolers, air conditioning equipment, low temperature drying ovens, etc.

HASKELITE T.M. Reg. *structural materials for men who build better*

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measures working temperatures

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. . . ACCURATELY

• MELTS SHARPLY — Tempil° products have a sharp and rapid melting action at stated temperatures . . . are available in *liquid, crayon,* or *pellet* form, as a convenient means of signalling temperatures in a multitude of industrial operations.

• READILY IDENTIFIED — Each Tempil° product is clearly marked with the temperature at which it melts. In addition, Tempil° products are made in a *distinguishing* color for each melting point.

• ACCURACY — Tempil° products have a mean accuracy of within 1% of stated temperature.

• USES — Tempil° products are widely used to: prevent cracks and failures in metal processing; make stronger and safer welds; repair costly castings, forgings and machine equipment; in hard-surfacing, straightening hardened parts, drawing, tempering and local heat-treating.

TEMPILSTIK° In 13° steps . . . 125° F. to 400° F. In 50° steps . . . 400° F. to 1600° F. For welding, forging, heat-treating and fabrication of metals; molding of glass, rubber and plastics, etc.

TEMPIL° PELLETS In 25° steps . . . 125° F. to 350° F. In 50° steps . . . 400° F. to 1700° F. To determine temperatures in heat-treating of large units or extensive areas; checking furnace or engine temperatures; setting induction-heater timers, etc.

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Write Gordon today for Tempil° Preheating Chart, Tempil° scale for weld bend testing and complete information on Tempil° products.

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News of...

ENGINEERS COMPANIES SOCIETIES

Works. His first work will be to study mineral resources of Arkansas and to what use they can be put.

Dr. *Ernest R. Hanson* has joined Foster D. Snell, Inc., consulting chemists and engineers, to head research and development in plastics and rubber. He has been with Bakelite Corp., is author of scientific papers, and is an inventor in the plastics field.

Norman B. Johnson has been appointed to the newly-created post of assistant executive vice-president, Pullman-Standard Car Mfg. Co. Among positions held have been die engineer, chief draftsman and assistant superintendent. More recently he was chief engineer of Pullman-Standard, later becoming manager of freight car plants.

William Uren, for 20 years master mechanic in charge of jigs and fixtures of Murray Corp., has become plant superintendent of the Lapeer Mfg. Co.

A. Douglas Dalton, for 33 years with Yale & Towne Mfg. Co., has been promoted from general superintendent to assistant general manager. Among his positions have been superintendent of methods, assistant engineer of manufacturing, work superintendent and general superintendent. *Harold E. Nagle,* for 28 years with the company, has been moved from superintendent of methods to general superintendent. Mr. Nagle is succeeded by *Frank J. Billingsley,* who has been in the methods department since 1931.

Stuart O. Fiedler has accepted a position as manager of research of the Industrial Rayon Corp., Cleveland. Mr. Fiedler will remain a director of Bjorksten Research Laboratories, but has resigned as manager of the South Chicago branch.

Companies

The *Permanente Metals Corp.* announces establishment of what it claims is the nation's largest technical laboratory devoted exclusively to aluminum fabricated products, being located adjacent to the Trentwood Rolling Mills, Spokane. Special emphasis is on pioneering in new alloys, overcoming corrosion and improving production techniques. Various subdivisions will deal with physical testing, finishes, fusion joining and corrosion. Heading the laboratory is Paul Ziegler, who has served metallurgically with both Alcoa and Reynolds Metals Co.

The *General Electric Co.* has opened a new plastics manufacturing plant at Coshocton, Ohio, which doubles the company's capacity for production of laminated plastics products. It replaces former G.E. facilities at Lynn, Mass. The largest press is of 5000-ton capacity, capable of producing laminated sheets, 50 by 100 in.

Maj. Jack W. Wheeler has organized

Assure

SAFE ARRIVAL of STEEL PARTS with ALOX

RUST INHIBITORS

● Insist on the use of ALOX 388-940-707 inhibitors for the maximum protection of steel parts during fabrication, assembly, storage and shipment.

Successfully used to protect overseas shipment of war equipment during World War II. Today these film forming rust preventives containing ALOX inhibitors are used in the control of corrosion of farm and construction equipment.

Write for literature on **ALOX** *products and where to buy the rust preventives containing* **ALOX**

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HIGH YIELD STRENGTH

FRONTIER ALLOY "40-E"

ALUMINUM Alloy THAT NEEDS NO HEAT TREATMENT

The ALLOY that has ALL 6

1. **Shock Resistance**—Tests have proved its exceptional ability to withstand explosive shock and standard impact shock.
2. **Corrosion Resistance**—Excellent, not only in standard corrosion tests but also under stress.
3. **High Yield Strength**—A dominant factor where distortion or misalignment of parts would make the assembly inoperable.
4. **Machineability**—Far superior to the usual sand cast aluminum alloys and machined parts have a high lustre.
5. **Pressure Tightness**—The fine grain of the alloy enables it to withstand high pressures.
6. **No Heat Treatment**—Physical properties are obtained by natural aging at room temperatures.

High yield strength is of utmost importance in castings subjected to severe stress and impact. This is especially true where distortion of the casting would render it functionally inoperative. Frontier "40-E" is notably high in yield strength—adaptable to many types of castings designed for exacting service conditions. In addition to its high yield strength, Frontier "40-E" also provides high tensile strength and elongation—properties attained through natural aging.

ENGINEERING DATA ON REQUEST

The Frontier Alloy Data Book brings pertinent engineering and metallurgical facts on the physical properties of "40-E". In writing for your free copy, please state company name, your title, and address.

Licensing franchises now available in certain areas to meet the increasing demand for Frontier "40-E" Alloy. Details on request.

Specifications — Army-Navy Aeronautical Spec. AN-A-17; U. S. Navy Bureau of Ships Spec. 46A-1 (INT), Class 1; A. S. T. M. Spec. B26-42T, Alloy ZG-41, S. A. E. 310.

Typical Physical Properties—tensile strength, 35,000 psi.; yield strength, 25,000 psi.; elongation, 5% in 2".

FRONTIER BRONZE CORPORATION

4874 PACKARD ROAD
NIAGARA FALLS, NEW YORK

News of...

ENGINEERS COMPANIES SOCIETIES

Wheeler Consultancy, Inc., 196 Worthington St., Springfield, Mass., as specialists in permanent molds. Activities cover mold design, manufacture, breaking-in, industrial styling, etc. He was formerly head of Rolls Royce Permanent Mold Foundry; also with *British Aluminum Co.* He is prominent in the affairs of the American Foundrymen's Assn.

The *Wallace Barnes Div., Associated Spring Corp.*, is building, through the *Turner Construction Co.*, a $2,000,000 industrial plant at Forestville, Conn., which is three miles from the main plant at Bristol. It will handle the heavier types of work connected with spring manufacture.

The *Pesco Products Div., Borg-Warner Corp.*, plans for immediate construction of a $120,000 laboratory in Bedford township, near Cleveland, to be used for testing aircraft fuel systems. The main plant at Pesco is one of the nation's largest manufacturers of hydraulic equipment. It makes specially designed pumps for all the rocket propulsion and ram jet projects now under way in the United States, being able to pump hydrogen peroxide, liquid oxygen, nitric acid and other light fluids.

The *Allegheny Ludlum Steel Corp.* has released its first non-technical motion picture, the "Legend of Useppa," or about fishing for the fighting tarpon. It is designed to be shown as a relaxer among the company's technical films on metallurgy and allied subjects.

The *Columbia Steel Co.* will build a cold reduction mill with a capacity to produce over 300,000 tons of sheets yearly in the Los Angeles area, the raw material being semi-finished steel in coils from the company's mill at Geneva, Utah. The completion date is end of 1949.

The *Morton-Gregory Co., Inc.* has been formed to manufacture and sell new industrial and consumer products calling for large scale use of Fiberglas yarns and other newly-developed materials, such as light metals and silicones. The company is headed by George E. Gregory, vice president, *Owens-Corning Fiberglas Corp.*

The *American Can Co.* has purchased a 46-acre site in Hillside, N. J. for a beer can factory which will be erected "with all possible speed to meet the enormously expanded postwar demand of Eastern brewers." A great American thirst for beer in cans for home drinking has developed, according to the company, partly because of returned servicemen who drank beer when water was impure—and on other occasions.

H. N. Muller, manager, educational department, *Westinghouse Electric Corp.*, states that engineering colleges report a 100% increase in the number of companies now interviewing their graduates in comparison to prewar. This manpower shortage will last well into 1949 or 1950, says Mr. Muller. Westinghouse is recruiting from colleges 100 more men yearly than before.

The *American Car & Foundry Co.* has booked an unusually large order, involving 36 all-aluminum tank cars for transportation of synthetic glycerine for *Shell Chemical Corp.* They are to be built at Milton, Pa., where there is a special gas-shielded arc process for welding aluminum tanks.

Societies

In view of the fact that not one student trained especially for the foundry industry was graduated last year from American engineering colleges, the *Northwestern (University) Technological Institute* has established a special curriculum for training students in engineering management problems of the foundry. Five undergraduate fellowships have been established. The new curriculum will include courses in metallurgy, tool and machine design, personnel studies and industrial management.

The *Instrument Society of America* has decided that its next annual meeting will be held at Philadelphia, Sept. 13 to 17, 1948, the exhibit to be set up in Convention Hall. Attendance at last September's convention was over 7000.

The *American Institute of Physics* will sponsor a new semi-popular magazine on physics, starting early next year, with David A. Katcher as editor. He has been with the Naval Ordnance Laboratory in Washington, D. C., and has authored a book on research.

At a recent meeting of *SAE National Aeronautics* of Los Angeles, E. M. Phillips, of General Electric's Aircraft Gas Turbine Div., stated that the best turbine wheel is a "composite"—a central disk of ferritic low temperature steel and an outer portion of high temperature austenitic material solidly bonded with an austenitic weld rod, with rigidly controlled processing.

Plastic patterns will be used for the first time in the national apprentice contest of the *American Foundrymen's Assn.* this year, being employed in nonferrous molding competition. R. G. McElwee, foundry division manager, Vanadium Corp., has been elected chairman of the Gray Iron Div. of AFA.

Attendance at the *Machine Tool Show* at Chicago during the 10-day period in late September was over 175,000, or nearly twice as many as had been anticipated.

A federal center of applied mathematics, the *National Applied Mathematics Laboratories*, has been established as a division of the *National Bureau of Standards*. It is oriented around modern mathematical statistics as applied to physical and engi-

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...good electrolytes

High conductivity of electro-cleaning baths which contain Metso Detergents speeds up grease removal. And, under high current density, Metso cleaning baths are stable. With Metso, also, you can be sure of spontaneous emulsification of oils, dispersion in the solution, and this "plus" advantage — protection from the re-depositing of removed dirt.

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Want to Weld Aluminum?

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Want fast, fine-looking welds with minimum distortion . . . free from oxidation . . . and without flux?

Want to conserve tungsten . . . save gas...use less power?

THIS NEW G-E INERT-ARC WELDER IS BUILT FOR YOU . . . *COMPLETE . . . COMPACT . . . CONVENIENT*

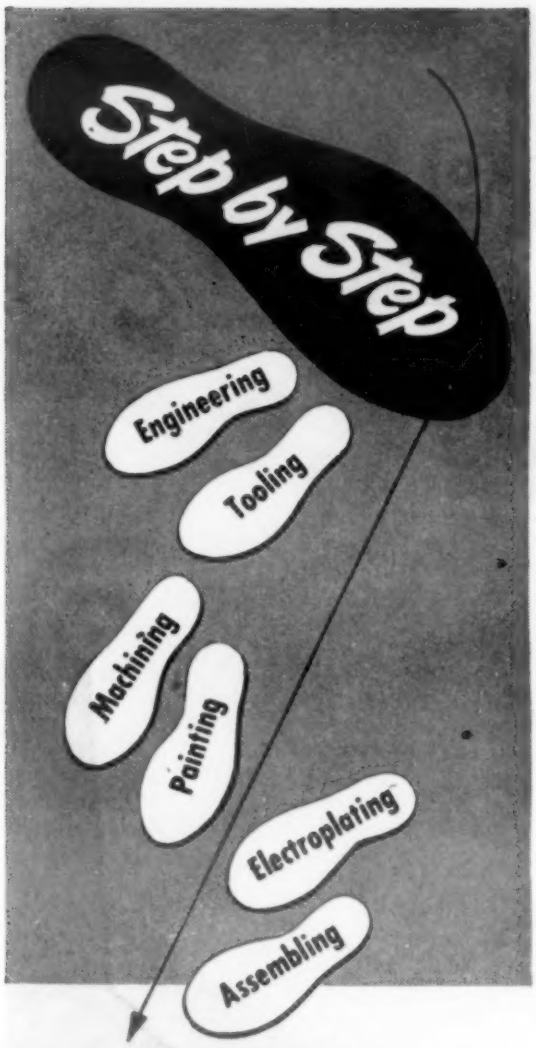
THIS NEW Type WP Inert-Arc welder is a completely self-contained power unit. Built into this single, compact welding set are: welding transformer—control panel—capacitors for power factor correction—a bank of series capacitors to stabilize the arc—a pilot spark circuit, which operates for only a fraction of a second during starting of the arc, thus eliminating objectionable radio interference during welding—and automatic water and gas solenoid valves.

The entire assembly is enclosed in a sturdy, drip-proof case, with electrical terminals brought out to convenient outlets. Welding current is controlled to any desired setting by turning a handle on top of the welder. An indicator scale on the front of the case shows the current setting. An "off-on" switch, mounted on the welder, makes it convenient to shut down the set when the job has been completed. A three-wheeled running gear, to make the set easily portable, is optional.

After initial adjustments have been made, all components of the welder are operated (through a control panel built into the set) by means of a simple foot-treadle switch supplied with the welder. This switch enables the operator to start or stop the current to the electrode holder—purge air from the gas hose and electrode nozzle prior to welding—change electrodes or electrode adjustment, when necessary, without current to the electrode holder and without entirely shutting down the machine. Use of the foot-treadle switch also permits gas and water to flow in order to let the hot tungsten electrode cool off without oxidizing. An automatic crater filler is optional.

For more detailed information about the Inert-Arc process and the new Inert-Arc welder, see your G-E Welding Distributor. Or write for G-E bulletin GEA-4704. *Apparatus Department, General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC



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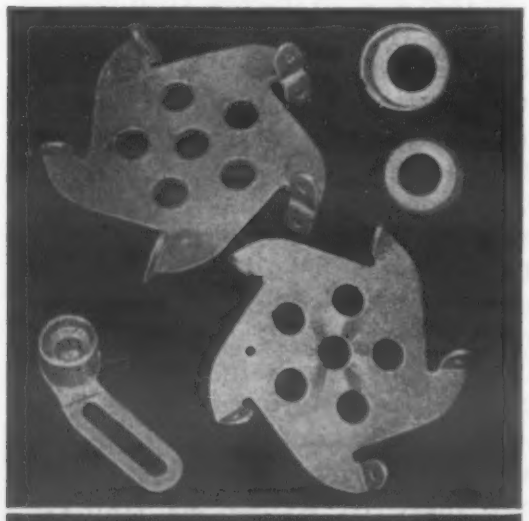

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News of...

ENGINEERS COMPANIES SOCIETIES

neering sciences and to the development and use of modern high-speed computing.

The *Southern Assn. of Science & Industry, Inc.*, Hotel Murray, Richmond, 19, will hold a Southwide Conservation Conference at Old Point, Va., Jan. 11 to 13 and will conduct a research conference in October, 1948.

Dr. C. H. Mathewson, professor of metallurgy at Yale, has received the gold medal of the *American Society for Metals* "for outstanding metallurgical knowledge and great versatility in the application of science to the metal industry, as well as exceptional ability in the diagnosis and solution of diversified metallurgical problems." Charles E. Hook, president, American Rolling Mill Co., has received its medal for the advancement of research for 1947.

Joseph Gordon Magrath is now functioning as executive secretary, *American Welding Society*. He has been associated with welded product design as far back as 1917.

The *American Iron & Steel Institute* is conducting four regional technical meetings at Philadelphia, Pittsburgh, Chicago and Boston. The last two are still to come, on Nov. 14 for Chicago and Dec. 10 for Boston.

The *Welding Research Council of the Engineering Foundation* reports progress in the pressure vessel research program costing $75,000 a year. About $30,000 has been allocated this year to the study of pressure vessel design at Purdue University.

Meetings and Expositions

NATIONAL ELECTRONICS CONFERENCE. Chicago, Ill. Nov. 3-5, 1947.

AMERICAN SOCIETY OF BODY ENGINEERS, annual convention. Detroit, Mich. Nov. 5-7, 1947.

SOCIETY OF AUTOMOTIVE ENGINEERS, air transport meeting. Kansas City, Mo. Dec. 1-3, 1947.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. Atlantic City, N. J. Dec. 1-5, 1947.

EXPOSITION OF CHEMICAL INDUSTRIES. New York, N. Y. Dec. 1-5, 1947.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Electric Furnace Steel Committee, annual meeting. Pittsburgh, Pa. Dec. 4-6, 1947.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. New York, N. Y. Dec. 4-6, 1947.

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YOU can lower plating rejects and improve lustre on finished steel parts by adding small amounts of Oakite Composition No. 3 to your burnishing barrel.

Oakite Composition No. 3 Offers 5 Big Advantages:

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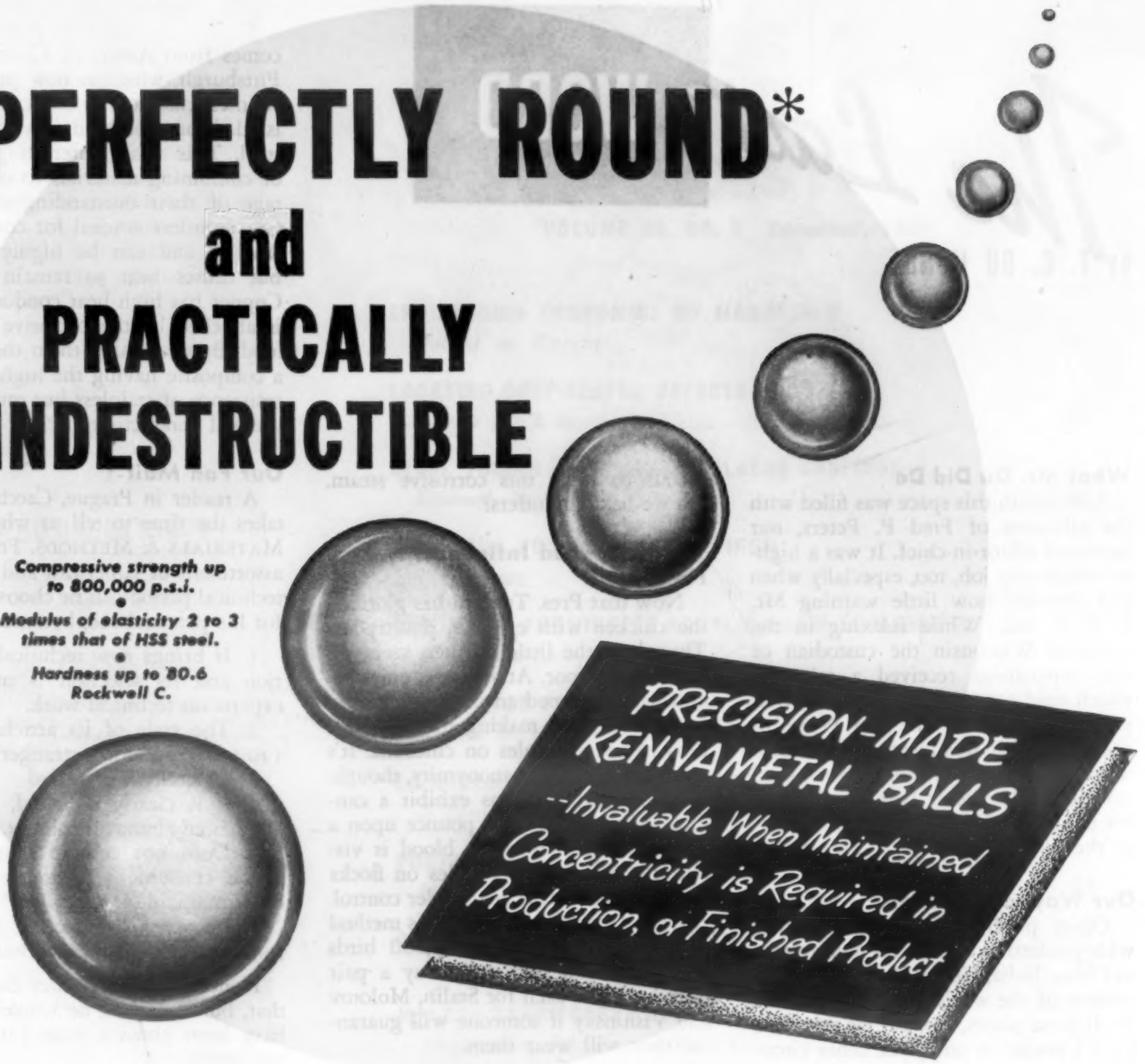
PRACTICALLY INDESTRUCTIBLE



Compressive strength up to 800,000 p.s.i.

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Modulus of elasticity 2 to 3 times that of HSS steel.

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Hardness up to 80.6 Rockwell C.

Kennametal Balls are made of an incredibly hard Kennametal composition, having a uniform, close-grained physical structure that permits the surface to be given a mirror-like finish that retains its lustre, and is non-galling. Due to precision processes that we have developed, these balls can be supplied, ground and polished, to within twenty-millionths of an inch of perfect roundness.

This accuracy, plus high resistance to wear, corrosion, and deformation, ideally suits Kennametal balls for hole sizing, check valves, Brinell testing, and other applications where resistance to abrasive wear, shock, and heat are essential.

Here are two typical examples:

- *As many as 20,000 valve tappet holes in automobile cylinder blocks have been sized with Kennametal balls, without appreciable wear; whereas steel balls wore to undersize after sizing 1,600 holes.*
- *Kennametal balls held tolerance and concentricity while sizing 60,000 hardened steel bushings, 3/4" long; while steel balls on the same job produced only 600 sizings. Use of Kennametal balls practically eliminated rejects, and saved approximately 90% of time required to check gage of holes sized with steel balls.*

Kennametal balls are available in nineteen standard sizes, ranging from 1/32" to 1-11/16". Smaller sizes can be supplied to order.

** To within twenty-millionths of an inch.*

KENNAMETAL

SUPERIOR CEMENTED CARBIDES

TRADE MARK REG U. S. PAT. OFF.

KENNAMETAL *Inc.*, LATROBE, PA.

The Last WORD

by T. C. DU MOND

What Mr. Du Did Do

Last month this space was filled with the effusions of Fred P. Peters, our esteemed editor-in-chief. It was a highly satisfactory job, too, especially when you consider how little warning Mr. F. P. P. had. While relaxing in the wilds of Wisconsin the custodian of this department received a telegram which read something like this: "Will you write October 'The Last Word' or shall I?" What was meant to be a gentle reminder looked to me like a kind invitation. The least that can be said for me is that I did wire back "thanks" to the offer.

Our Wayward Readers

Other publications boast of their wide readership in such far away places as China, India, Upper Darby and other corners of the world. We have readers in all those places, too, but we think we have a reader in one place other circulation managers have not yet reached. At least a recent mailing bill showed one item:

Air Express to St. Joseph...$2.59.

This would seem to prove that some of our readers are a little *higher* than the angels.

Pluto as an Operating Engineer

This department goes from one extreme to another. It now comes to our attention that Pluto might be forced to carry a union card. An Italian group is visiting in this country trying to purchase a power plant to use steam generated underground in volcanic areas of Italy. Water piped down to hot strata is returned as steam at about 50 psi. and will be used to help coalless Italy industrialize. Pluto is not as completely tractable as this would seem, however, for the grade of steam sent up would quickly whiten the hair (if it left any) of any American power plant operator. Sulfurous gases are the worst of the contaminants. All that is wanted is now is a metal or group of metals to resist this corrosive steam. Do we hear any offers?

The Hollywood Influence, No Doubt

Now that Pres. Truman has glorified the chicken with egg-less, poultry-less Thursdays, the little red hen seems to go in for glamor. At any rate, one steel mill has developed an interesting little sideline business making stainless steel pins to keep goggles on chickens. It's not all a passion for anonymity, though. It seems that chickens exhibit a cannibalistic tendency and pounce upon a wounded comrade when blood is visible. By placing red goggles on flocks this ferociousness is kept under control. A careful check shows that this method can save 250 chicks per 5,000 birds per season. I'll personally buy a pair of red goggles each for Stalin, Molotov and Vishinsky if someone will guarantee they will wear them.

What Next Department

Perhaps you overlooked it, but last month one of our items made reference to a brand new metal characteristic. As a matter of fact, even the author who used the term can't define it, but it does go to prove that you'll always find the latest first in MATERIALS & METHODS. What's this all about? Well, in an item describing "Elvinar Extra", a new watchspring alloy, it was stated, and we quote: "and modulus of *electricity* varied with changing temperatures." If any one wants to substitute *elasticity* for *electricity* we'll not quibble or stand in his way.

A Boon to Their Wives

Someone stated that even their wives had difficulty in appreciating metallurgists. Now, however, there is a development which should elevate metal men in the eyes of their wives. Cooking utensils which resist food sticking to them and capable of being washed merely by immersing in hot, soapy water should do the trick. This promise comes from American Cladmetals Co., Pittsburgh, which is now producing a stainless-clad copper sheet. The copper is clad on both sides with stainless steel. This is an interesting example of combining materials to take advantage of their outstanding characteristics. Stainless is ideal for corrosion resistance and can be highly polished, but causes heat to remain localized. Copper has high heat conductivity but is attacked by the corrosive action of food. By combining them there results a composite having the high corrosion resistance of stainless but much higher thermal conductivity.

Our Fan Mail

A reader in Prague, Czechoslovakia, takes the time to tell us why he likes MATERIALS & METHODS. From a vast assortment of American and European technical periodicals he chooses M & M for his personal use, because:

1. It brings *new* technical information and its selection is made from experts on technical work.
2. The style of its articles is clear (an advantage for a stranger).
3. Its content is varied.
4. It is clearly arranged, attractive, and has an abundant content.
5. Does not contain market news which consume very much space in other magazines.
6. Its advertising section is very informative and of high technical value.

Honest, our copywriter didn't write that, but if he had he would probably have been given a raise (at least for the ideas).

A Prophet's Without Honor

The irreverence of one's fellow workers is somewhat disheartening. For instance, one of our associates refers to this page as the "Last Will." Upon giving the matter some consideration, though, he might have something in that name, for it is our intention to leave the reader something, even if it be only a pleasant grin or a slight chuckle.

Hotter Than —

Hades is getting a little competition from Linde Air Products Co. Now Linde comes along with a device that should be of considerable value in mining. It is a fusion piercing rig that melts hard rock with a petroleum-base-and-oxygen flame, aided by a flux. The molten mass created is then broken up by squirting water on it. 'Tis said to be many times as fast as a churn drill. The office semi-wit says the "hot-rocks" herein referred to should not be confused with stolen gems.